Ministry
of
Education
Ontario

Authorized by the Minister of Education.
Hon. Bette Stephenson, M.D., Minister
Harry K. Fisher, Deputy Minister

HEC
73.1909715
59DE/C-1

STORA

CURRICULUM GUIDELINE FOR THE

Intermediate and Senior Divisions

1983

COMPUTER STUDIES

Introductory Computer Studies (Intermediate)

Computer Science (Senior)

Computer Technology (Senior)

Data Processing (Senior)

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The Ministry of Education also appreciates the extensive input from the validators of this document. Many improvements have been incorporated into the document as a result of their involvement.

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Preface

This guideline outlines the expectations of the Ministry of Education for the development of computer studies courses in the Intermediate and Senior Divisions. Any course developed from this guideline shall be based on the goals of education outlined on pages 6 and 7 of this document.

This document supersedes the following guidelines:
- *Computer Science, Senior Division, 1970;*
- *Data Processing RP.33, 1966;*
- *Elements of Computer Technology, Senior Division, 1970;*
- *Informatics, Intermediate and Senior Divisions, 1972.*

Existing courses based on previous guidelines should be made consistent with this document by September 1984. In cases where established courses that do not fall within the scope of this guideline merit ministry approval for their continuance, such approval may be obtained, on an annual basis, according to the procedures set out in *Ontario Schools: Intermediate and Senior Divisions, 1984.*

No other field of study is likely to be in such a state of flux in the coming years as is computer studies. The use of computers is likely to increase significantly in the elementary schools. It is expected that the number of courses involving the study of computer technology will grow. In addition, changes in technology, as well as in the social and business uses of computers, are likely to occur. For these reasons it is expected that it will be necessary to review the guideline on a regular basis to determine what changes, if any, might be required. As well, although the program in computer studies outlined in this document has been designed to provide a balanced and up-to-date set of learning experiences for secondary school students, it will be necessary for principals and teachers to make careful but flexible use of this guideline to provide courses that clearly meet the diverse needs of their students.

It is recognized that not all of the courses set out in this document will be provided by every school. Principals are expected to provide a selection of courses that will meet their students' needs and abilities. In addition, principals may wish to develop alternative courses, for partial or multiple credits, using the procedures referred to above. Finally, while the program outlined in this guideline has been designed to provide the best possible direction to schools, it is recognized that principals may wish to vary the grade at which any course is given or to waive prerequisite requirements so that a school's courses will serve the interests and capabilities of its students, while still fulfilling the requirements of this guideline.

Introduction

Computers have had, and will increasingly have, a profound effect on many areas of life. As a result of the widespread use of new technological processes based on microelectronics, our society is rapidly changing from one shaped by the needs of industrial production to one dependent on the creation, use, and communication of information for its economic and social well-being. A major tool in the handling of information is the computer. Technological advances have already made the computer commonplace in our private lives, in the arts, in the workplace, and in education. Thus, in addition to acquiring the traditional basic skills (reading, writing, and computation), today's students must be computer literate in order to function effectively in society, to understand the world, to benefit from technology, and to gain access to the information it provides and the processes it controls.

Students must be prepared to respond to the changes in the workplace, in technology, and in society caused by the computer revolution. This guideline provides a comprehensive framework for the development of computer-related courses. Students should be encouraged to select from such courses a program with the particular emphasis that best reflects their present capabilities and interests, as well as their future needs.

The following subsections are provided for those who require a broader understanding of the scope of the use of computers in society. It is this scope that provides the basis for the rationale for this guideline.

Computers in Daily Life

Computers are used widely to cope with thousands of pieces of information and millions of calculations. For example, an individual's medical, insurance, banking, credit, and tax records are now stored in computer-based systems. Since computer communication networks facilitate wide access to such information, every individual has a responsibility to know what types of information are electronically stored and whether this information is being used in the best interests of the individual and of society.

Computers also have many uses in homes. Specialized computers are used to improve the efficiency and safety of such common items as thermostats, microwave ovens, watches, and automobiles. Multi-use computers can assist in the managing of household finances, facilitate writing and correspondence tasks through their word processing capability, and act as entertainment and learning centres. Increasingly, an individual will be able to use a home computer to communicate over telephone or cable lines with other computer users and to access material stored in electronically managed data banks. In this way information and educational courses will be readily available to suit each individual's specific needs.

Computers in the Arts

The computer is increasingly being used as a creative tool in the arts. Word processing software has brought a new freedom to those who must capture and edit original thought by making it easier to record ideas and subsequently to refine them.

Today's graphic artists can use computers to experiment quickly and efficiently with different shapes, colours, compositions, and textures. In addition, computers can be used to explore other aspects of the artistic process. For example, objects can now be represented on the screen in three dimensions and may be rotated so that all sides may be viewed. The computer also permits artists to work in the field of animation with a minimum of equipment and in a fraction of the time involved using more traditional methods.

In the world of music the combination of the microcomputer and the synthesizer has made possible "music processing", thus facilitating the writing, harmonizing, and scoring of music.

When used effectively by professionals, sophisticated computer equipment allows musicians to allocate much more time to the creative process than they could in the past. As well, inexpensive units are available for people who want to learn more about music and to become involved in the creative process themselves.

Computers in the Workplace

It has been estimated that a significant part of our gross national product is now produced directly as a result of information processing. Today's workplace offers many careers that either directly or indirectly require computer knowledge and expertise. In addition to those directly related to the design, repair, operation, or programming of computers, almost every occupation is affected by the computer in some way. For example, accountants require training in computer auditing, clerks use computer terminals for order entry, and mechanics use computers in electronic diagnostic systems. Changes in computer technology are constantly outdating traditional careers, while they create new occupational needs.

Computers in Schools

Computers can serve many purposes in schools:

- They can enhance and extend dynamic processes of learning (sensing, creating, synthesizing, analysing, simulating, and communicating).
- They increase the extent to which the content, process, and pace of learning (including the acquisition of basic knowledge and the development of the skills required to formulate and express ideas through words, numbers, and symbols) can be adapted to the needs of the individual.
- They help students acquire the basic skills necessary for careers based on computer technology.
- They facilitate the assessing, recording, and evaluating of student learning.
- They extend student access to a broad range of information and enable students to manipulate that information effectively. In many fields of post-secondary education students will be expected to use computers or videotex devices in their studies, searching for electronically stored information and compiling and testing statistical data for research.
- They facilitate the development of a variety of delivery systems for education.

Exceptional Students

The use of the computer is important to the educational needs of all students. In addition, gifted students benefit from the increased scope computers provide for creativity. For handicapped students the computer can be used:

- to increase language capability or writing skills through the computer's word processing facility;
- to assist those with organizational and learning-skills problems to overcome these problems through the use of special software;
- to increase motivation;
- as a "prosthesis", by providing them with alternative methods of communication, memory ability, or the ability to control their environment.

The Computer as a School Resource

In the same way as the skills of reading and writing enabled a person to function effectively in the past, computer knowledge and skills might assist current and future generations to function more effectively and to increase their understanding of the nature of the society in which they live.

Computers are already being used in a number of classrooms throughout the province for other than computer studies courses. As the cost of computers decreases and the availability of good educational software increases, the use of computers by teachers to support programs will become commonplace.

The following statements are presented as a guide for teachers who are using computers to support various educational activities:

- Since the use of computers in the classroom is relatively new, their potential in the learning process is not fully known. Teachers are encouraged, therefore, to explore the capabilities and applications of computers and to share their experiences and understandings with their fellow teachers.
- Like television, films, filmstrips, textbooks, and other learning materials, the computer has a valuable role to play in supporting the learning process.
- Formal computer courses such as those outlined in this guideline for Grades 10-12 are not expected in Grades 7-9. (See the chart of authorized courses in the next section of this document.) However, units of study developed with a balance similar to that incorporated in the Grade 10 courses outlined in this document may be used in elementary schools.
- Where appropriate, computers should be used to enhance all subjects rather than being limited to one specific subject area.
- Some students, in addition to using prepared programs, will want to create their own. They should be encouraged and assisted by the teacher to do so. However, computer programming should not be expected of all students.
- As students use the computer in various subject areas, they will become aware of what a computer is and how it works. In addition, teachers are urged to investigate with their students, within the context of the ongoing program, the many ways in which the computer may be used and its effects on society.

Computers also have an important role in the school's library resource centre. In this regard the centre should provide:

- access to information about the computer software that is available within both itself and other resource locations within the school, the board, other local schools, and the community;
- an interlibrary loan service to make such resources available to students and teachers;
- equipment, such as microcomputers or terminals, that makes possible the independent use of lessonware and courseware;
- access to information data bases such as Info Globe and other Telidon-type information.

Thus, it might be a school staff objective to make the library resource centre an access point for on-line catalogues of various types of resources, and to the resources themselves.

Sex Equity

Computer studies courses are equally appropriate for girls and boys. All students should be encouraged to use the computer as a problem-solving and creative tool. For example, information processing and language processing (word processing) are computer functions that are equally useful to all students. The computer studies program in the school should be carefully designed to overcome any sex-role stereotyping that might exist.

Developing a Computer Studies Program

The Goals of Education in Ontario

The Ministry of Education in Ontario strives to provide in the schools of the province equal opportunity for all. In its contribution to programs, personnel, facilities, and finances, the ministry has the overall purpose of helping individual learners to achieve their potential in physical, intellectual, emotional, social, cultural, and moral development. The goals of education, therefore, consist of *helping each student to:*

1. DEVELOP A RESPONSIVENESS TO THE DYNAMIC PROCESSES OF LEARNING
Processes of learning include observing, sensing, inquiring, creating, analysing, synthesizing, evaluating, and communicating. The dynamic aspect of these processes springs from their source in many instinctive human activities, their application to real-life experiences, and their systematic interrelation within the curriculum.

2. DEVELOP RESOURCEFULNESS, ADAPTABILITY, AND CREATIVITY IN LEARNING AND LIVING
These attributes apply to modes of study and inquiry, to the management of personal affairs such as career plans and leisure activities, and to the ability to cope with challenge and change.

3. ACQUIRE THE BASIC KNOWLEDGE AND SKILLS NEEDED TO COMPREHEND AND EXPRESS IDEAS THROUGH WORDS, NUMBERS, AND OTHER SYMBOLS
Such knowledge and skills will assist the learner in applying rational and intuitive processes to the identification and solution of problems by:

   a) using language aptly as a means of communication and an instrument of thought;
   b) reading, listening, and viewing with comprehension and insight;
   c) understanding and using mathematical operations and concepts.

4. DEVELOP PHYSICAL FITNESS AND GOOD HEALTH
Factors that contribute to fitness and good health include regular physical activity, an understanding of human biology and nutrition, the avoidance of health hazards, and concern for personal well-being.

5. GAIN SATISFACTION FROM PARTICIPATING AND FROM SHARING THE PARTICIPATION OF OTHERS IN VARIOUS FORMS OF ARTISTIC EXPRESSION
Artistic expression involves the clarification and restructuring of personal perception and experience. It is found in the visual arts, music, drama, and literature, as well as in other areas of the curriculum where both the expressive and receptive capabilities of the learner are being developed.

6. DEVELOP A FEELING OF SELF-WORTH
Self-worth is affected by internal and external influences. Internally it is fostered by realistic self-appraisal, confidence, and conviction in the pursuit of excellence, self-discipline, and the satisfaction of achievement. Externally it is reinforced by encouragement, respect, and supportive evaluation.

7. DEVELOP AN UNDERSTANDING OF THE ROLE OF THE INDIVIDUAL WITHIN THE FAMILY AND THE ROLE OF THE FAMILY WITHIN SOCIETY
Within the family the individual shares responsibility, develops supportive relationships, and acquires values. Within society the family contributes to the stability and quality of a democratic way of life.

8. ACQUIRE SKILLS THAT CONTRIBUTE TO SELF-RELIANCE IN SOLVING PRACTICAL PROBLEMS IN EVERYDAY LIFE
These skills relate to the skilful management of personal resources, effective participation in legal and civic transactions, the art of parenthood, responsible consumerism, the appropriate use of community agencies and services, the application of accident-prevention techniques, and a practical understanding of the basic technology of home maintenance.

9. DEVELOP A SENSE OF PERSONAL RESPONSIBILITY IN SOCIETY AT THE LOCAL, NATIONAL, AND INTERNATIONAL LEVELS
Awareness of personal responsibility in society grows out of knowledge and understanding of one's community, one's country, and the rest of the world. It is based on an understanding of social order, a respect for the law and the rights of others, and a concern for the quality of life at home and abroad.

10. DEVELOP ESTEEM FOR THE CUSTOMS, CULTURES, AND BELIEFS OF A WIDE VARIETY OF SOCIETAL GROUPS
    This goal is related to social concord and individual enrichment. In Canada, it includes regard for:
    a) the Native peoples;
    b) the English and French founding peoples;
    c) multiculturalism;
    d) national identity and unity.

11. ACQUIRE SKILLS AND ATTITUDES THAT WILL LEAD TO SATISFACTION AND PRODUCTIVITY IN THE WORLD OF WORK
    In addition to the appropriate academic, technical, and interpersonal skills, this goal relates to good work habits, flexibility, initiative, leadership, the ability to cope with stress, and regard for the dignity of work.

12. DEVELOP RESPECT FOR THE ENVIRONMENT AND A COMMITMENT TO THE WISE USE OF RESOURCES
    This goal relates to a knowledgeable concern for the quality of the environment, the careful use of natural resources, and the humane treatment of living things.

13. DEVELOP VALUES RELATED TO PERSONAL, ETHICAL, OR RELIGIOUS BELIEFS AND TO THE COMMON WELFARE OF SOCIETY
    Moral development in the school depends in part on a consideration of ethical principles and religious beliefs, a respect for the ideals held by others, and the identification of personal and societal values.

The preceding goals are not arranged in any hierarchical order, nor are they discrete categories from which a checklist should be made. The integrated nature of learning and the complex pattern of human development preclude such a sequential or fragmented approach. The translation of the goals into classroom objectives, however, will undoubtedly result in sequences of learning appropriate to the particular levels and stages of development of the students for whom programs are being planned.

Aims for Computer Studies

The goals outlined above will be realized in part through the achievement of the following aims for computer studies courses. Such courses should provide students, through individual and group experiences, with opportunities to:

- evaluate the significance of information processing devices in their personal lives and in society;
- use the computer in creative ways;
- use the computer and its software to carry out repetitious tasks, as a creative tool for such purposes as creative writing (word processing), or to write a simple computer program to carry out a personal task;
- understand how computer technology is used in everyday life and develop their capability to use devices based on it;
- appreciate the technological achievement and potential accruing from the development and creative uses of the computer and other high-technology devices;
- become aware of the computer's capability for problem-solving;
- use the computer in activities that involve them in decision-making and problem-solving;
- appreciate the specific benefits and possible problems that have resulted, particularly in Canada, from technological achievements;
- become aware of the availability of the information that is electronically stored, updated, and manipulated by computers, as well as the potential for the misuse of information about individuals;
- evaluate their own attitudes and values as these relate to the possible uses and abuses of computer technology in society;
- appreciate that work is a desirable activity that results in satisfaction, provides opportunities for acquiring additional knowledge and skills, and makes a contribution to society.

These aims are reflected in the intent outlined in the first paragraph of each of the course guidelines contained in this document. The intent is realized through the achievement of the major objectives, which in turn are realized through the achievement of the enabling or secondary objectives. In the development of local courses, strategies, processes, and topics will be established to facilitate the realization of each enabling objective. Appropriate evaluation strategies will also be developed to assess the extent of student achievement in this regard.

The Focus of Courses and Programs

Each of the aims outlined above should be reflected in each course. Since courses must be designed to accommodate the diverse needs and capabilities of students, the emphasis on individual aims will vary with different groups of students.

General-level courses should enable students to develop computer literacy, as well as to acquire the skills, knowledge, and attitudes that they will require to acquire and succeed in a job. Some general-level courses will provide the basis for college programs that are designed to extend and refine the vocational skills acquired in secondary school.

Basic-level courses will focus on assisting students to develop computer literacy and personal life skills, especially communication skills. In addition, students of basic-level courses may acquire certain skills, attitudes, and work habits that they will require to enter the work force.

Advanced-level courses must prepare students to develop the attitudes, skills, and understandings that they will need to continue their work in computer studies beyond secondary school. In this regard the statements already made for basic- and general-level courses also apply to advanced-level courses. Communications, citizenship, aesthetic awareness, and personal skills of various kinds are essential components of most advanced-level courses, although the prime emphasis of such courses will be on academic preparation of students for further study.

Authorized Courses

The accompanying chart outlines the authorized courses in computer studies and a recommended sequence for them. It is assumed that the teaching strategies and evaluation practices of these different courses will reflect the different objectives outlined in the specific guideline for each course. While each of these objectives should be considered core, the depth to which each enabling objective is emphasized is left to the discretion of the teacher. Time lines are provided within each course guideline as a suggestion of the amount of time that might be allotted to each major objective.

Due to the evolving nature of the subject matter, specific topics have not been identified. What have been identified are the skills and concepts that should remain valid for a number of years, despite changes in technology.

Any of the courses authorized by this guideline may be adapted for students who have been identified as exceptional pupils and who require special education assistance.

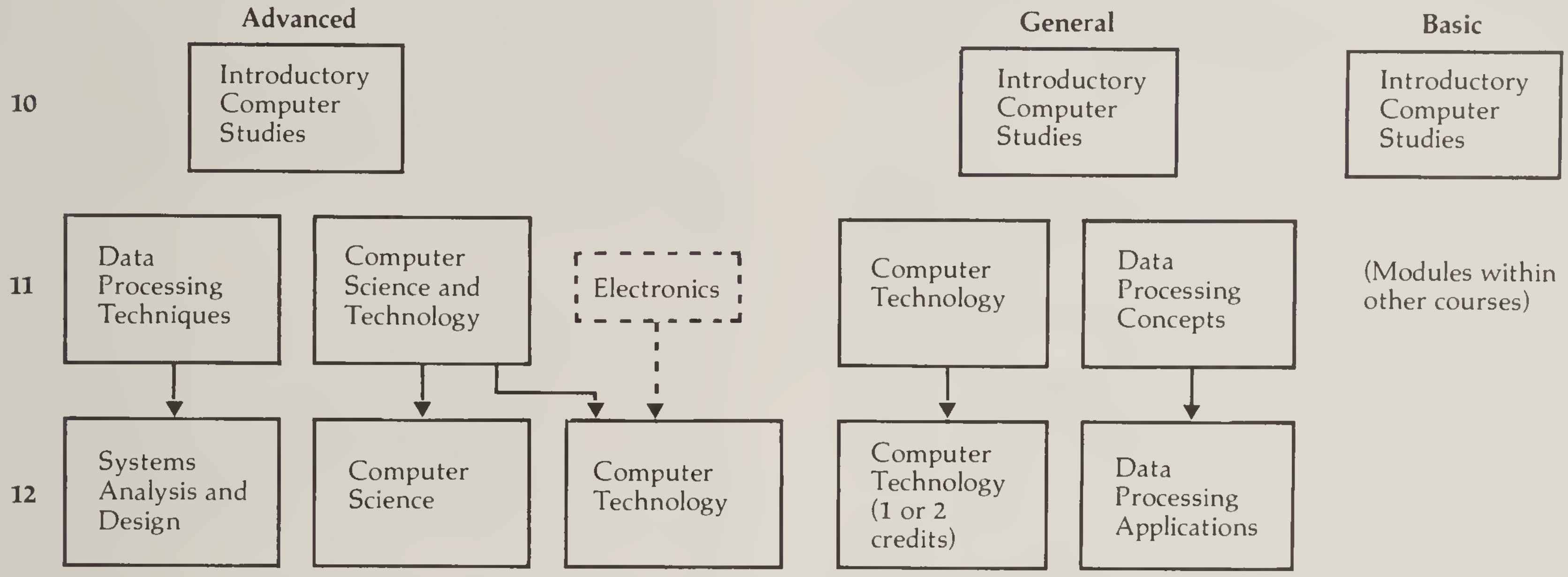
The teaching suggestions outlined for the Introductory Computer Studies courses include direction on developing units of instruction for computer literacy or awareness prior to Grade 10.

Prerequisite Courses

The prerequisite courses that are considered appropriate are shown in the diagram on page 9. Schools must provide clear information on such recommended prerequisites to students and parents. No courses shall be identified as prerequisites other than those so recommended in this guideline.

In cases where individual students or parents request exemption from a recommended prerequisite course, the principal of the school will rule on the request. Should the principal deny the request for exemption from such a course, the parent or adult student may appeal to the school board, whose decision shall be final.

Computer Studies Program


Advanced
General
Basic
10
11
12
Introductory Computer Studies
Introductory Computer Studies
Introductory Computer Studies
Data Processing Techniques
Computer Science and Technology
Electronics
Computer Technology
Data Processing Concepts
(Modules within other courses)
Systems Analysis and Design
Computer Science
Computer Technology
Computer Technology (1 or 2 credits)
Data Processing Applications

Each block represents the authorization for a single-credit course except where noted otherwise. The Grade 12 courses are linked by arrows to their recommended prerequisites.

At the time of writing, Ontario Academic Courses in computer studies are planned.

Roles in Program Development

While the Ministry of Education establishes goals, policies, and specific expectations through its curriculum guidelines, it is the responsibility of each school board, through its supervisory officers, principals, and teachers, to ensure that courses of study consistent with this guideline are available in all schools offering such courses, to plan and co-ordinate local curriculum development, and to assist those staff members who are responsible for developing courses of study and materials based on this guideline. The ministry, through its regional offices, will ensure that this guideline is delivered to local school boards and will monitor its implementation.

Staff development is an essential component of school board planning and co-ordination. Planning for in-service programs, especially on professional activity days, ought to focus on key issues that affect curriculum implementation. Faculties of education are also expected to use this guideline in the preparation and delivery of pre-service and in-service courses for teachers.

This guideline provides the direction that educators require to plan and teach specific courses. Once the implementation of this guideline is initiated in the schools, it is the responsibility of board supervisory officers and principals to ensure that the expectations of the guideline are being met.

Courses of study developed from the guideline shall be on file in schools, and their effective use in classroom programs shall be monitored through regular visitations and evaluations by principals or supervisory officers.

It is essential that meaningful curriculum review and renewal take place on an ongoing basis. The effectiveness of this curriculum guideline depends on communication, co-operation, and co-ordination among the ministry, school board officials, and teachers. This co-operative effort is essential to assure the continual improvement of learning experiences for students.

Evaluation

Introduction

The evaluation of student achievement and program effectiveness must be an integral, ongoing part of the teaching-learning process. This evaluation can serve the following functions:

- to provide the student with information concerning what he/she has already mastered and what still needs to be learned;
- to provide parents with information regarding their child's progress;
- to verify the appropriateness of stated goals and objectives;
- to provide information that will enable teachers to modify the program as needed;
- to assess the quality and effectiveness of the learning strategies and materials that have been used;
- to spur the student to further achievement.

The wide variety of activities in computer studies courses involves a number of kinds of thinking skills. For example, programming involves analysis and translation, whereas systems design involves evaluation and synthesis. It is appropriate, therefore, to design the assessment and evaluation of student progress and achievement to reflect these different types of thinking processes.

Student work may be evaluated on a daily basis. Such evaluation could take into consideration competency in using computer hardware, ability to work within a group, punctuality or lack of it, ability to follow instructions, compliance with housekeeping and safety routines in the shops, and personal initiative.

Some measure of the progress of individual students in completing assigned work could also form part of student evaluation. This might be derived from the terms of a learning contract or the completion of specific units of work and bonus assignments.

Course components that can be organized around terminal performance objectives — activities that the learner will be able to do — are especially suited to evaluation based on competency. For example, students taking a data processing course at the general level are expected to operate a computer system using software that is commonly used in a business. In such cases various computer operations may be defined as terminal performance objectives. The criteria for competency testing could then be established.

Students exploring areas of interest may demonstrate creativity, originality, organizational skills, and writing ability through projects, reports, and essays. Where such activities are to be evaluated, the way in which they are to be assessed and their relative importance in the total evaluation should be clearly outlined in advance.

Short tests or quizzes may be used to assess student progress. Ideally, these should be used for formative evaluation. Where the results of such tests are to form part of the students' summative evaluation, the tests should be carefully designed to reflect the clearly established objectives of the unit of work being tested.

Traditional summative tests or examinations could also be used in the evaluation process, particularly in advanced-level courses. Ideally, this type of evaluation should be carefully designed to evaluate a range of mental operations, such as translation, interpretation, application, analysis, synthesis, evaluation, and divergent thinking. Before such operations are formally evaluated, students should be given sufficient opportunities to practise writing responses to sample questions.

It is desirable that student evaluation employ a wide range of methods. In this way a more accurate assessment of progress may be obtained. Since not all students are comfortable with any one method, the excessive use of one particular mode of evaluation could significantly affect the result of some students. The use of diverse methods of assessment should assure fair and equitable results. A comprehensive outline of a variety of assessment methods is presented in *Science, Intermediate Division, 1978*. Teachers are encouraged to review this outline prior to establishing assessment strategies for computer studies courses.

The suggestions outlined in the sections that follow are provided to assist teachers in developing assessment systems that have been used successfully in computer studies. Teachers may use these techniques as a basis in developing their own methods of assessment, which would be adapted to meet the needs of particular groups of students.

Evaluation in Basic-Level Courses

Teachers of Introductory Computer Studies at the basic level have to develop a very flexible evaluation system which is closely related to the individual needs of each student. For example, students with reading or writing difficulties would have to be assessed through the use of testing methods that involve a minimum of reading and writing. Credit should be given, however, to the student who is able to improve his/her skills in these areas. The following is an outline of some general evaluation methods that have been used successfully by teachers of basic-level courses:

- The teacher establishes an evaluation system composed almost entirely of bonus marks. In such a system the teacher is constantly looking for some positive activity and awards the student a bonus mark in the mark book each time one is observed. A student might merit a bonus mark, for example, when he/she follows a series of instructions, becomes somewhat more co-operative in class, promptly settles down to a task, or sees a particular project through to completion.
- The teacher evaluates the progress of a student. Early in the course the teacher establishes a benchmark for the student in a variety of areas. With some coaching the student makes progress, which the teacher then evaluates.
- The teacher evaluates the degree to which students have met clearly defined objectives. In this case a variety of tasks are established and posted in the classroom. They can include a wide range of things, such as demonstrating good work habits, showing courtesy to peers, reading a book written at an appropriate level, or completing a project. Whenever the teacher notes a student involved in an activity that matches or is similar to one that has been posted, a mark is awarded to that student. Periodically the teacher could sit down with each student to analyse the marks that have been entered so that the students may identify areas of progress and areas in which more work is needed.

The various topics in Introductory Computer Studies lend themselves to a variety of modes of evaluation. For example, teachers could make up a checklist of the various steps involved in operating the computer. They would then be able to observe their students and check off the steps that the students are able to do particularly well and those that require more practice.

In order to function effectively with others involved in the use of the computer, students need to be able to use appropriate terms. Teachers can evaluate student understanding in this regard by listening to how their students dialogue with their peers, by giving the students an oral examination, or by having the students label diagrams related to the computer and its peripheral equipment.

Students may be evaluated on their understanding of computer technology by being asked to explain to the teacher or another student how something works. For example, they might explain the concept of a circuit by demonstrating how it may be formed by a battery, wires, and a light bulb. Alternatively, they might choose to use an analogy to get the point across, for example, by relating a circuit to the human circulatory system.

Teachers can listen to classroom and group discussions in order to assess whether or not students appreciate the changes that the computer is causing in our society and are aware of the benefits that high technology is providing those workers who are able to make use of it. The progress that students are making in understanding that a successful business requires dedicated and productive workers may be similarly assessed. Alternatively, the degree of industry and promptness that students demonstrate in their day-to-day classroom activity might be used to assess their understanding of the importance of dedication and productivity.

There is usually a considerable amount of dialogue when students are using the computer in pairs or small groups. Students could be encouraged to assist each other by explaining or illustrating how to do something. The way in which students communicate in this mode could then be used as a basis for evaluation. Students who are able to write out simple instructions or to construct block diagrams of procedures should receive credit for this type of communication.

Evaluation in General-Level Courses

The techniques outlined above can also be used to assess students who are taking general-level computer studies courses. Students taking Computer Technology, for example, will be evaluated on their lab or shop activities, including their ability to follow the safety procedures that have been established. The projects students plan and carry out could be evaluated not only for the quality of the work involved but also for the way in which they were approached, the ingenuity involved in their conception, and the planning and development that went into them.

Evaluation in the technology area is generally straightforward. Assigned projects and written reports can be assessed. In fact, when written reports form part of student evaluation, a higher standard of project work usually results.

Student experiments with circuits are difficult to assess; however, they can be used to evaluate testing and trouble-shooting skills. Defective circuits can be wired and students can be assessed on their ability to find the trouble in a fixed period of time. A team approach is sometimes used, in which one group will create circuit problems which a second group will try to find; this method generates interest and sharpens student skills.

Logic gates provide a useful means of assessing students. Problems of machine control can be presented and students required to develop the necessary logic to solve them. Students can also be presented with a logic system and be required to reduce it to a simpler form. Such methods create interesting challenges for students and make evaluation more diversified and thus more realistic. However, teachers should be careful to ensure that most of the problems and challenges presented are within the capability of the average student in the class. Otherwise some students could become discouraged and feel that they lack potential for success in this area.

Various types of assessment techniques can be used to identify the students' understanding of concepts. These could include having students sketch diagrams, label diagrams that have been provided, or use available materials to demonstrate a concept.

If suitable resource materials are available, students should be encouraged to read and prepare reports on some aspects of computer technology. They could also be required to read about and then translate a process into a series of step-by-step procedures. They could be evaluated on how well they understand the material and on the quality of their reports.

Specific assessment strategies in general-level courses must reflect the objectives of these courses. For example, the focus of the Grade 11 and 12 general-level data processing courses is on the operation of the hardware and the use of available software. Teachers can use check sheets to evaluate how well each operation is performed. After an appropriate amount of practice, students could be evaluated on how accurately they enter data and their facility with the software being used.

Traditional modes of evaluation could be used to evaluate the degree to which students have mastered various concepts. Where possible, such evaluation should be linked directly to the practical activity in which students are involved in the classroom. For example, if a student has been working on a unit of work on word processing, the student should be able to relate that type of activity with, or extrapolate from it, concepts about electronic mail.

If the teacher chooses to evaluate students on the analysis of an issue, it is suggested that a background paragraph be provided the student along with a series of questions that require relatively short answers. These will help students to organize their thoughts and reach a conclusion or final statement on the issue.

Students should be encouraged to design their own short projects that will demonstrate their creativity and ingenuity. They should also be encouraged to read appropriate materials and to communicate either orally or in writing what they have learned from those materials.

Evaluation in Advanced-Level Courses

The skill requirements of post-secondary studies will affect the assessment strategies used in advanced-level courses. The focus should be on assessing the development of a wide range of academic skills. These include research, organizational, communication, and problem-solving skills.

A variety of techniques can be used to evaluate the quality of a program that a student writes. One technique is to deduct marks for bad form from the total marks available. Considerable marks would be deducted for bad logic. For example, if a program contained only one significant logic error that would be easy to correct so that the program would run successfully, it could be assigned a mark of, say, fourteen out of twenty. However, if the logic errors indicated that two or three significant modifications would be necessary before the program would run, then, clearly, the teacher would not assign the program a passing mark.

One technique for evaluating programs written without direct supervision is to "validate" completed programs by having the student write out the code of a program, under supervision. The teacher then evaluates this program to make sure that the concepts that the student should have been mastering while doing the assignments have in fact been learned. An unsatisfactory test would require a make-up test. An unsatisfactory make-up test might cause the teacher to invalidate the projects that were handed in or to require that additional programming assignments be carried out.

Teachers should be cautious of basing too large a proportion of their total evaluation on the assessment of a student's program. Sometimes a program is developed as a co-operative effort rather than by the person claiming authorship. In such cases the mark assigned might not accurately reflect the effort or programming ability of the student. Programs written on a microcomputer pose additional assessment problems. Such programs may be listed if a printer is available. In such cases teachers could examine the listing and evaluate the quality of the program's design, style, and documentation. As an alternative, teachers could observe a "run" of the program, requiring that it process certain test data, and could have modules of the program listed to see how certain procedures were coded.

It is important that, after completing their initial programs, students develop appropriate programming style. They should clearly understand what is required in developing a modular, hierarchical program. Thus, the listed modules of the student programs described above could be marked in a similar way to which an essay is marked. Each well-designed module is similar to a well-written paragraph. The way in which all the modules are linked together is similar to the overall cohesion of an essay. Teachers should establish the standards for programming style and documentation and then provide adequate time for students to measure their developing skills against the teacher's expectations. Evaluation techniques should be developed so that students are given full credit for well-designed, well-structured, and, when appropriate, well-documented programs.

If a group of students is to form a programming team to develop a complex program, the teacher should spend considerable time at the beginning of the project briefing the students on how the project will be marked. Considerable emphasis should be placed on the need for each student to contribute to the best of his/her ability. One technique used to measure or evaluate this contribution is to design a type of ballot, which students fill out confidentially, on which they rank the contribution of each member of the team except themselves. This information is used, along with the teacher's own observations of the group process, to establish a mark that is fair to each student in the group. Students who make extraordinary contributions to projects should not have their mark reduced due to the unwillingness or inability of other team members to make a significant contribution to the programming project.

Since research projects provide students with opportunities to explore in some depth topics that are of interest to them, research should be encouraged. In order to assure that all students in the classroom are aware of the teacher's expectations in this regard, written assignment sheets should be provided. These sheets could outline the scope of the project, suggest methods of approaching the task and the specific style of the report or essay, and provide a specific outline of the way in which it will be marked. As well, a significant number of students work best when a model is provided for them to peruse or study in some detail.

Some school staffs have established committees to develop a style manual for the school. Such a manual outlines different types of written assignments that might be produced and includes some suggestions on how to go about approaching a research project or report. The manual could also include the form and rules for footnoting, the form for bibliography listings, a statement as to what is public-domain information and what not, a clear statement on plagiarism and the policy of the school with respect to it, and a reminder of the traditional structure of a paragraph and how paragraphs are used within the structure of a report or essay. Students appreciate a manual such as this, especially when it includes a section on how the essay or report might be marked. Such manuals avoid confusion on the part of the students, who may have to write essays or reports for a number of different teachers representing different departments. The common terminology, common form, and a similar approach to evaluation reduce significantly any misunderstanding that students might have while doing assignments for a number of teachers.

One of the goals of advanced courses is to help students develop their research and writing skills. It is the responsibility of computer studies teachers to help achieve this goal. Strategies should be developed to guide, coach, or instruct students with this in mind, and assessment strategies should reflect this effort.

Intermediate Division Courses

Introductory Computer Studies, Grade 10 (General)

Introduction

This course should provide students with opportunities to obtain a broad understanding of the integration of computers in society, to explore various functions of the computer, and to acquire basic computing skills. Computer technology should be explored at the conceptual level. Provision should be made for the examination of the impact of computers on society and the issues raised by the changes taking place in information processing.

It is intended that the course focus be on those areas of knowledge that lead to further study and those skills that may be developed more fully in subsequent courses. The knowledge and skills acquired during the course should prove invaluable not only within the context of a career or subsequent courses, but also in terms of the student's personal life.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in eight broad areas.

1. *Using application programs on the computer*

Students should become comfortable using a preprogrammed computer to carry out a task through the development of the following skills and understandings:

a) the ability to turn a computer on and off, read routine status messages, key in commands to load a program, and run a program;
b) an understanding of the functions of the main parts of the computer, particularly the visible parts, and the use of the terms *input, output, microprocessor,* and *memory;*
c) the ability to select appropriate data for input when prompted by the computer;
d) the ability to interpret the output;
e) an understanding of the nature of a program and, in general terms, how the computer uses a program;
f) an understanding of the need for auxiliary or secondary storage;
g) an increased ability to listen to or read and follow very short lists of operating instructions, prepare short lists of operating instructions for other students to follow, and describe for other students something related to the operation of the computer;
h) the understanding that the computer and its programs are tools that may be used effectively by people with very little training.

2. *Programming the computer*

Students should acquire the ability to write or modify a simple program through the development of the following skills and understandings:

a) the ability to list a program and, on direction, alter an instruction to create a different output;
b) the ability to write a program that (i) simply results in a short endless loop, (ii) comes to a logical end, and (iii) produces first a title and then a repeated routine that comes to a logical end;
c) the ability to read diagnostic messages and to act accordingly;
d) the ability, by studying a very simple program containing an easily correctable error, to correct the error and to run the program to verify the correction;
e) the ability to listen to program instructions given by the teacher or another student, to give oral program instructions to another student, and to write a very short program on paper;
f) the ability to outline or list the steps involved in developing a method or procedure for carrying out a non-computerized task;
g) the knowledge and comprehension of sample safeguards that could be part of a computer program.

3. *Impact of computers on society*

Students should examine various classes of computer applications so that they may evaluate the impact that these applications are having on society in general and on the individual in particular. This will require an understanding of the following:

a) the many uses of the computer in our society;
b) the extent to which the microcomputer is used in diverse and unusual ways;
c) the implications and consequences of this wide use of computers;
d) the responsibilities of government and professional computing associations in directing the evolution of information processing, including maintaining effective controls;
e) the responsibility of individuals to be aware of areas of possible abuse of computers and of the remedies available should such abuse occur;
f) the rapidly occurring changes in technology and how these are affecting society.

4. *Computer technology*

Students should understand the function of a variety of computer hardware components and obtain a general understanding of how they work through the exploration of the following:

a) the nature of a simple electrical circuit;
b) some electronic principles of microcomputer technology, including AND, OR, NOT, and flip-flop concepts;
c) the function of electricity in making the computer function, for example, the way in which information is communicated from one part of the computer to another (bus concept);
d) how data and instructions are stored in code by the turning on or off of individual *bits* of information (conceptual understanding only);
e) how combinations of switches create this code;
f) the function of a number of computer-related devices (i.e., disc and tape) and the way in which they operate (conceptual understanding only);
g) the rapidly occurring changes in technology and how these are affecting society;
h) the diverse number of technological jobs that exist and the training, personal characteristics, and attitudes needed to be successful in some of them.

5. *Information processing*

Various *types* of information exist. Students should obtain an understanding of how information is used through an exploration of *one* or *two* examples of each of the following:

a) sources of information;
b) ways in which information is created and processed;
c) types of information classification and some of the ways in which information is disseminated;
d) ways in which the computer and its related equipment are used to process information;
e) data structures and the various ways of organizing data;
f) ways in which people communicate with each other and with machines;
g) the impact, both positive and negative, that electronic communication has had and is having on our society;
h) trends or changes in the way that information is currently being communicated in the home, in business, and among nations;
i) modes of effective communication;
j) concerns or issues related to information storage and retrieval;
k) the needs for effective communication in an individual's personal life and in the world of work.

6. *Careers and further studies in computing*

Students should be provided with opportunities to explore the various educational paths and careers related to computer studies through the exploration of the following:

a) the many classifications of careers directly related to computers;
b) ways in which information processing affects many of the workers in our society;
c) how computers are changing the ways in which people function in small businesses;
d) educational possibilities available in the students' own and neighbouring schools for further studies related to computers;
e) further educational and training possibilities in computer studies;
f) detailed studies of two or three information processing careers of personal interest.

7. *Computers and the work ethic*

Employers of computer personnel have certain expectations. Students should examine their personal attitudes and work habits in light of those expectations in order to develop an understanding of the following:

a) the relationships between the expectations of the workplace on the one hand and classroom and shop routines on the other;
b) the profit motive of employers and reasons why profits and losses occur;
c) the need for personal time management;
d) the need for good communication between an employee and an employer;
e) their own attitudes towards different types of work so that they can modify any misconceptions that they may have;
f) the fact that good workers involved in work related to computers usually need a number of different skills to carry out their daily tasks;
g) the parts of tasks that may be repetitive or boring and those that are interesting and challenging, and the need for self-discipline in the performance of tasks without direct supervision.

8. *Communication skills*

Students should enhance their personal communication skills by practising effective listening, speaking, reading, and writing through such tasks as the following:

a) listening carefully to and following oral instructions;

b) reading and following clearly written instructions such as those found in hardware and software manuals;
c) reading and interpreting orally for others various types of computer output;
d) writing instructions for the operation of a program or a device, or a brief description of the functions of programs.

Introductory Computer Studies, Grade 10 (Advanced)

Introduction

This course should provide students with opportunities to explore in depth the components of and the wide range of procedures related to computers and other high-technology devices, to learn how to use such devices to personal advantage, and to gain an insight into the impact of such devices on society. Students should be challenged by short, intensive introductions to computer concepts and skills, including those related to programming, computer technology, data processing, and computer science.

Each student must have an opportunity to consider his/her own aptitude in relation to the requirements of the fields of data processing and computer science, as well as to technological applications of computers. It is intended that this course provide a sound, broad background for subsequent, more specialized courses.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in eight broad areas.

1. *Operating the computer*
Students should learn how to operate a computer and its peripheral devices and to obtain a conceptual understanding of the internal operations taking place, including the following skills and understandings:

a) the ability to turn a computer and its peripheral devices on and off, to load and run programs, and to enter suitable information when directed by the program;
b) the ability to use correctly the proper names of the major external and internal parts of the computer and its peripheral devices;
c) an understanding of how software interrelates with hardware to carry out a task;
d) the ability to follow oral and written instructions for the operation of a computer, as well as to prepare a short series of instructions for the operation of a peripheral device for others to follow;
e) the ability to list a program and, on specific oral or written directions, to alter one or more of the instructions within the program to cause it to produce a different output.

2. *Programming the computer*
An introduction to programming should provide students with information and skills so that they are able to:

a) appreciate how a few instructions will cause a computer to produce considerable output;
b) learn ways by which data or information may be entered into a computer;
c) write simple routines that will illustrate the three basic operations involved in the processing of information — sequencing, selection, and repetition;
d) use problem-solving techniques to develop solutions in programming applications;
e) understand and practise good program design;
f) synthesize the various aspects of programming by satisfactorily analysing a program statement, developing a logical approach for its solution, writing the instructions in a computer language, testing and debugging the program, and adding suitable internal documentation.

3. *Impact of microelectronic technology on society*
A variety of opportunities should be provided for students to explore and evaluate the impact of the widespread use of computers on society. This will require an understanding of the following:

a) the diverse uses of computers in society;
b) some of the issues and consequences related to these widespread uses;
c) the various safeguards available to protect individuals against the misuse of the computer that exist or that should exist at the international, national, local, and personal levels;
d) the recent changes that high technology has brought about in society, current trends, and possible consequences of these trends.

4. *Computer electronics*
Students should acquire a general understanding of the electrical and electronic structure of the computer through the explanation of the following:

a) the nature of a circuit and the need to provide the correct voltage to make a computer function;
b) the function of the various types of gates or circuit modules that make up the computer's logic, including AND, OR, NOT XOR, NAND, NOR, and flip-flop concepts;
c) the function of the flip-flop for storing information inside the computer;
d) the organization of the internal architecture of the computer and the need for communication among the various components;
e) the principles of operation of one or more peripheral devices, such as the electromagnetic principles involved in auxiliary storage devices;
f) the extent of energy consumption (or power rating in watts) of computers and peripheral devices.

5. *Information processing*
Students should gain an understanding of information processing through the exploration of the following:

a) the techniques used in collecting, recording, verifying, and storing information;
b) how to illustrate the flow of information within a business and among businesses;
c) the various operations used to process information;
d) the fact that information processing is a system of operations and procedures that involves the integration of information, hardware, and people;
e) how to illustrate or describe in general terms file and data-base organization;
f) data-access methods in terms of society's concerns regarding privacy;
g) the evolving impact of computer and videotex communication on society;
h) the variety of careers available in the field of information processing;
i) the aptitudes and skills required for the various careers in information processing;
j) the variety of courses offered in information processing.

6. *Computer science*
Students should develop a clear understanding of the world of computer science, including the following:

a) the diverse careers in computer science;
b) educational paths that lead to these careers;
c) programming and non-programming tasks that are commonly done by computer scientists.

7. *Computer-related careers*
Students should be provided with opportunities to investigate some of the many strands of the computer field that may be considered for further in-depth study and that lead to careers based on or related to computers through the exploration of the following:

a) careers related to hardware and software;
b) courses, skills, and aptitudes that lead to post-secondary school programs or directly to employment;
c) possible computer-related career targets.

8. *Communication skills*
Students should enhance their personal communication skills by practising effective listening, speaking, reading, and writing through such tasks as the following:

a) reading and interpreting orally for others a range of material (technical manuals, descriptions of sociological issues pertaining to high technology, etc.);
b) researching and preparing formal reports or essays on topics and issues related to computers.

Introductory Computer Studies, Grade 10 (Basic)

Introduction

This course should provide students with opportunities to obtain a general understanding of various aspects of computing and the use of technology in their everyday lives. An emphasis should be placed on operating the computer and on using programs written by others. Students should develop the ability to select and accurately enter input data and to analyse critically and interpret output. An emphasis should also be placed on the impact of technology on the home and workplace. The types of background, work habits, attitudes, and skills required for working with information processing technology should be explored.

It is intended that this course provide information and skills to those students who will find the computer and other common technical equipment incidental tools in the workplace or in their personal lives. Some students might discover an aptitude for some aspect of computing and pursue this interest by taking additional courses.

Objectives

A course developed to reflect the intent outlined above should assist students to achieve the following objectives. For convenience these objectives have been listed in six broad areas.

1. *Using the computer*

Students should become familiar with the operation of technological devices that may be employed in the home, in the marketplace, or at work through the development of the following skills and understandings:

a) the ability to safely and correctly turn a microcomputer on and off, load a program, and follow the program's simple instructions;
b) an understanding of the function and care of a cassette or disc drive;
c) the ability to select the correct information from some source and enter it when requested by a computer program;
d) the ability to interpret computer output and especially the ability to check to see if it is reasonable;
e) the ability to operate and maintain common household technical devices (e.g., thermostats, microwave ovens, record players, tape machines), some of which are operated by microprocessor chips;
f) the ability to name the three main parts of the typical computer;
g) the ability to name common auxiliary storage devices;
h) an understanding in general terms of the nature of a variety of input and output devices (e.g., the ability to identify the input and output devices in a video game);
i) the ability to use a variety of microprocessor-driven devices (e.g., learning aids, video games, pocket calculators, watches);
j) the ability to use a variety of software that is designed and selected to be of a practical nature and of interest to the students;
k) the ability to perform basic banking functions, including using the automatic teller;
l) the ability to listen carefully to oral instructions about the use of the computer and to follow these instructions promptly and carefully.

2. *Programming concepts*

Students should become familiar with the concept of a computer program through the following activities:

a) running a program with the objective of noting the type of output; then listing the program and, on direction, altering an instruction; and, finally, rerunning the program to observe the change in output;
b) learning how to program the computer to print out their own names and addresses;
c) learning how to create a simple design using a repeated print instruction;
d) reading and following clearly written instructions on the operation of the computer or its peripheral devices;
e) instructing another person in the basic operation of a computer or a peripheral device such as a tape or disc drive.

3. *Impact of computers on society*

Computers are used both in the home and at places of both work and recreation. Students should learn of these uses through activities such as the following:

a) running a variety of programs that illustrates the diverse use of computers;
b) listening carefully to some of the concerns regarding the possible effects that computers may have on the individual and discussing these concerns;
c) discussing how computers make our economy more productive and therefore provide us with a better life, listening carefully to the opinions of others, and expressing clearly their own reasoned opinions;
d) discussing how computers are used by people to increase their independence (including the use of computers by the handicapped).

4. *Computer hardware*

Students should be provided with opportunities to develop an awareness of some of the many commonly used electronic devices, including the following skills and understandings:

a) the ability to operate electrical devices safely;
b) an understanding of how electrical current activates a piece of equipment by sending pulses from one part of the device to another;
c) the ability to use analogies to describe how electricity combines with the instructions of a program to cause a computer to do the things that it does;

d) an understanding of how motors are used to drive parts of devices, such as tape drives or discs;
e) the ability to perform simple cleaning and maintenance operations for selected pieces of equipment;
f) the ability to read and interpret instructions and illustrations for hooking up components of a system, such as a new stereo system or a computer with its peripherals.

5. *Using computers in a career*
Students should be provided with opportunities to explore careers involving the use of various computer-related devices and to develop the following skills and understandings:

a) a knowledge of the various types of computer-related devices used in the everyday world;
b) an understanding of the ways in which some of these devices could be of personal use, either currently or at some time in the future, particularly in education;
c) an awareness of additional courses in computer studies that may be of interest and use to them;
d) an awareness of possible career options open to them as a result of their computer knowledge or skills.

6. *Employers and computers*
The expectations of employers of computer personnel should be identified, and students should examine personal attitudes and work habits in light of those expectations in order to develop an understanding of the following:

a) the relationships between the expectations of the workplace on the one hand and classroom and shop routines on the other;
b) the need for personal time management so that projects are completed efficiently and effectively;
c) the relationship between the degree of effort applied to any computer-related task and the amount and/or quality of output that can be expected;
d) the profit motive of employers and the reasons why profits and losses occur;
e) the fact that good workers involved in work related to computers usually need a number of different skills in order to carry out their daily tasks;
f) the need for self-discipline in the effective performance of tasks for oneself or for others without direct supervision;
g) the need for good communication among co-workers and between an employee and an employer.

Teaching Suggestions for Introductory Computer Studies (Basic, General, and Advanced)

The course content provides opportunities for a wide variety of student activities, ranging from sociological ones to technical activities. Within this spectrum of activities students should be given opportunities to acquire and practise a range of academic skills, such as translation, application, analysis, synthesis, and evaluation. Students should be involved in discussions, practical projects, problem-solving, and the use of the computer as the course proceeds.

The challenge for the teacher is to design a balanced course that will develop the latent interest of all of the students in the class. For example, some students who have not previously had the opportunity to explore their interests in an area such as computer technology might discover a flair for it. Others might become interested in sociological issues. The skilful teacher will attempt to develop each discrete topic with equal enthusiasm. In doing so, the teacher should attempt to identify within each major topic a variety of activities that are suitable for study. Instruction must go beyond the learning of facts to include active learning experiences. As well, programming should include processes that go beyond analysis. Students should have regular opportunities to use computer equipment throughout the course.

Since many of the course objectives are interrelated, projects or discussions should be designed to reinforce these relationships. An overriding objective is to have students practise the skills of effective listening, speaking, reading, and writing through such tasks as the following:

- listening carefully to and following oral instructions;
- reading and following clearly written instructions;
- reading and interpreting orally a range of materials (written instructions, clearly written manuals, etc.);
- writing instructions or brief descriptions for others.

Computer hardware. The use of correct terminology in oral and written work is essential to clear thinking about computer operations. Students should become familiar with this terminology in ways other than those that rely on pure memory work. Most of the computer hardware terms should be introduced to students in the initial part of the course. This can be best accomplished by exposing the students directly to the computer at the outset. The course content can also be developed through the use of diagrams, pictures, exhibits, simulations, and games. Terminology should be continually related to the everyday world of the students. For example, the chalkboard, pen, notebook, calculator, television set, and radio have functions analogous to those of the computer.

The approach to teaching input devices varies with the hardware used in the school. Hardware components can be related to the various senses and the capabilities of the human brain. Where the keyboard is the sole means of input, proper keyboard skills can be introduced. (Students should be urged to take a keyboarding course prior to or concurrently with this course.) Keyboard drills using text-editing software can also be used. The emphasis should be placed on the need for maximizing human skills in order to better utilize the speed of the equipment.

Computer technology. The hands-on approach is an effective way to present the material on computer technology. It is desirable that students have access to relatively simple circuits, perhaps activated by a 6 V battery. A variety of experiments may be undertaken, including using combinations of logic gates and light-emitting diodes. A significant number of students will find this type of activity extremely interesting. Assistance from educators with a background in technology might be necessary in order to develop a sound, cohesive unit.

In dealing with the central processor, teachers can introduce the relationship among the control, arithmetic-logic unit, and storage. This relationship can be applied in the treatment of other topics that deal with programming and with the limitations of computer systems. The functions of the control, arithmetic-logic unit, and storage can be simulated at the chalkboard or by using a mock-up of the computer's components. Software is available to illustrate the internal operation of the computer. A demonstration of this program would show how low-level instructions manipulate data.

Hardware concepts may be taught in terms of changes that have taken place in technology over time. Present trends in storage capacity can be examined to produce estimates of what future memory devices and media may be like. The characteristics of storage devices and media can be compared. The same type of comparative study can be applied to input and output devices.

Where video-display units are the sole means of output, classroom discussions can centre on various types of video displays (colour, black-and-white, amber, etc.), the resolution of graphics (high or low), plasma screens, the number of characters displayed across the screen, and the number of lines displayed from the top of the screen to the bottom. Classroom discussions should encompass the appropriateness of output devices for particular applications. This could lead to the treatment of such forms of output as speech, tones, and process-control signals.

If printers are available, the various types can be examined. Paper sizes, lines per page, and the number of print positions per line can all be examined, and students can be shown a variety of preprinted forms. The routine maintenance of a printer can be explained, and, where appropriate, students could learn to replace printer ribbons, to change paper stock, and so on. The trend towards a "paperless" society should also be discussed.

Data representation. While data representation may prove fascinating to some students, it should be remembered that computers do the conversions from one code to another and that very few workers in the industry devote themselves to the mechanics of this task. Thus, the emphasis should be placed on the uses of the various coding systems. The treatment of this topic could lead to a consideration of the principle that the central processing unit sends and receives information impartially; that is, input messages from a keyboard and a card-reader are essentially the same to the computer regardless of the physical characteristics of the device. The concept that relatively simple code conversions are used to provide useful structures for information (meaningful to us and manipulatable by a computer program) should also be developed.

Using the computer. Students must have hands-on experience with a computer for a significant period of time throughout the course, ideally on a daily basis. Part of the time would involve programming with the balance of the time spent using prepared programs. Where computer facilities are not available in the classroom, the objective of this part of the course can be achieved through co-operative education, work experience, or field trips.

It might be advantageous to spread the experience with the computer over the duration of the course rather than devoting a single block of time to it. This would allow students of varying ability to complete programming assignments in a reasonable time and reduce the possibility that students who are progressing more slowly than others will have incomplete assignments. It would also give students time to consolidate what they have learned.

It is important for students to appreciate that the program is the animating factor within the computer. The steps involved in the execution of a computer program can be taught using pencil-and-paper simulations of the operation of the computer system. The following are some of the key concepts of the interrelationship of the program with the computer hardware:

- The instructions are transferred from secondary storage to main storage.
- The central processing unit obtains one instruction at a time from main storage and executes it.
- Data are obtained from an input device or from main storage.
- Numeric data are processed in the ALU.
- Processed data are stored in main storage or secondary storage, or sent to output.
- A multi-program computer system requires many types of programs to allow it to service the various needs of the user.

The analysis of typical high-level instructions draws out the component parts of an instruction — instruction number, operation, and the operands.

The way in which data in storage locations are altered under the control of a program can be best demonstrated by using short programs written in a high-level language. Computer simulations are available to show how a hypothetical low-level language functions. Such a brief demonstration is useful. However, students benefit very little from writing out codes in a hypothetical low-level language because of the time involved, and, in most cases, the frustration and aggravation that result. More detailed study of a hypothetical low-level language could be carried out as a project by those few students interested in computer architecture, and by students who are being introduced to architecture in Grade 12 Computer Science.

Programming is a difficult task for many students. While some readily acquire an understanding of programming concepts, others encounter considerable frustration. Teachers should be sensitive to this fact and should be prepared to use a variety of strategies. For example, two or three of the initial assignments could involve supplying students with fully coded programs to be keyed into the computer and run. In this way the students can readily achieve successful runs. Additional problems can then be assigned with important program instructions omitted; the students would be required to supply these. Some teachers use a team approach, assigning up to three students to carry out a programming task. Students can also be asked to read over programs written by others to find errors in the programs and to predict output. It is important to introduce the concepts of structured or modular programming as early as possible so that students develop a good programming style.

Experience has shown that too much programming discourages a significant number of students, while at the same time distorting their perception of the broad range of computing vocations that exists. After a brief introduction to programming, students should have the opportunity to continue programming on an optional basis, developing complete solutions to programs from a clear problem statement. This additional programming might be used as a means of screening students who wish to select a subsequent course involving intensive programming. Such screening would identify those students who really do have an interest in and an aptitude for programming and who are not being misled by the relatively straightforward introduction to programming suggested for this course.

Teachers are encouraged to explore the use of LOGO as a programming language for those students who have difficulty with a high-level algorithmic language.

Problem-solving. This topic can include problem recognition, classification, and definition. The types of problems selected by teachers, and perhaps by students, to practise problem-solving techniques could include both those whose solutions could be implemented on the computer and those having solutions that are inappropriate for computer applications. The latter have certain definite solutions and include games, puzzles, and problems related to pollution, economics, energy, politics, society, and so on. Students can be introduced to the techniques of research and analysis that can be used to gather information to solve problems. Libraries or resource centres are useful in this regard. When dealing with problem-solving, students can examine the following techniques: heuristic reasoning, dividing a problem into subproblems (modularizing), brainstorming, lateral thinking, diagramming or writing out solution steps, simulating, hypothesizing, and using decision tables and tree diagrams.

Students should be aware that there are a variety of problem types, including those that have well-defined solutions, those that have a multiplicity of solutions, those that have an optimal solution, and those that have no solution. They should also be aware that not all problems have computerized solutions. Examples discussed could be taken from a variety of fields, such as business, science, technology, sociology, government, and so on. Students should recognize that there is often a clear connection between a type of problem and the strategy or technique selected to find the solution. Care should be taken, however, not to overdo the development of algorithms for mundane tasks such as getting ready for school.

Computer applications. The computer is increasingly becoming part of the lifestyle of each individual. A significant amount of time should be set aside to examine some of the changes that have taken place in the use of the computer. This, in turn, should help to give meaning or relevance to other parts of the course. Since a historical approach to this topic could be a dull experience for some students, a good strategy would be to develop the concept that the evolution of devices is based on needs that are present at specific times and that each new device creates pressures for the development of still other devices.

The material to be considered initially can be developed through textbook assignments or through independent student research in books and periodicals. For example, students can research some or all of the following:

- early tabulators and first-generation computers; Hollerith and Powers — unit-record equipment; Howard Aiken — Mark 1; John William Mauchly and John Presper Eckert, Jr. — ENIAC; John von Neumann; EDVAC; UNIVAC 1;
- the birth of the computer industry;
- second-generation computers (IBM 1400);
- third-generation computers (IBM 360).

Computer applications can be considered throughout the course. For example, they can be used to introduce a discussion of particular components of a computer system or they can be treated as an independent topic. The applications demonstrated or discussed should initially reflect an effective use of the computer rather than one that lessens the computer's credibility. With this in mind, applications should be carefully chosen on the basis of the availability of software and hardware. The following are some current computer applications that might be discussed in the classroom.

- *accounting and record-keeping:* payroll; student records; inventory control; banking; retailing; airline reservations; medical data;
- *statistical:* sales analysis; sports records; election results; census records; educational records;
- *information-retrieval:* legal information; libraries; videotex systems; government data bases; insurance records;
- *simulation and gaming:* space exploration; car and building design; city planning; flight analysis; military research; scientific experiments;
- *forecasting:* environment planning; weather forecasting; economic and social planning; sales projections;
- *monitoring and process-control:* medical applications; quality control; oil, steel, and chemical processing; traffic control; robots used in manufacture;
- *educational:* computer-assisted learning; class scheduling; career selection; test scoring; attendance records;
- *scientific:* structural design; medical research; space exploration; circuit design;
- *microprocessor-control:* home appliances; automobiles; robots;
- *physical-faculty aids:* hearing; vision; limbs; speech;
- *word processing:* multiple uses in general and legal offices; magazine and newspaper preparation;
- *CAD/CAM:* computer-assisted design and computer-assisted manufacturing;
- *modelling:* developing new products or systems on the computer;
- *other:* new computer applications are constantly evolving.

The impact of computers on society. Students should consider both the positive and negative implications of the use of computers and should learn to consider carefully the effects of possible future computer applications. They should also understand the role that they may play in shaping future developments related to computers. Discussions should encourage students to examine the use of computers in society from both an individual and a global perspective. They should consider the adaptations necessitated by greater computer use in the home environment, in the work environment, and in society in general. Student debates are an effective means of elucidating conflicting viewpoints on these issues.

The following examples of the impact of information processing may help to stimulate student discussion and debate:

- *personal impact:* privacy and personal rights (data banks, computer terminals, data security); employment (job opportunities, new careers, the need for retraining); business transactions (automated billing, credit cards, consumer spending); the replacement of people through automation (robots, word processing); the impact that a machine has on a human (pros and cons);
- *community impact:* employment; urban planning; traffic control; law enforcement;
- *national impact:* communications media (the use of information for control); vote counting; electronic funds transfer; stock-market transactions; defence; surveillance; national data banks; employment (shifting patterns); telecommunications; satellite broadcasting; the possibility of fraud or theft using computer-based systems (*Note:* When this topic is covered, the emphasis must be on respect for legal, moral, and ethical values rather than on how fraud and thefts are committed.); the need for computer security and controls; standards for computer hardware and software;
- *global impact:* reporting of current events (communications media); world government; international standards; exploration of space and sea;
- *future impact:* computers in the home (gaming, learning, electronic mail, shopping, and information processing, storage, and retrieval); the home as a work centre; effect on the family unit and on familiar patterns of life; travel (computer communication as a replacement for travel); the possible disappearance of hard copy as a medium of communication; the cashless society; possible effects on the formal educational system; the use of robots in industry and in the home; teleprocessing networks (communications networks, worldwide access to data, distributed processing).

Library and media resources should be used in dealing with this aspect of the course. Films and videotape materials will expand student awareness of the importance of the computer in the modern world. Students can also use the many books and periodicals now available in the research they complete for individual projects. School library resource centres should be equipped with reference materials and software for student use.

Computer-related information and careers. Students should be provided with information about jobs and future education opportunities related to the computer so that they can make wise decisions in this regard. If possible, this topic should be completed early enough in the school year so that students will be able to select their options for the next year using the information they obtain as a guide.

Students should be provided with information on post-secondary education opportunities at the colleges of applied arts and technology, universities, and private vocational schools. They can visit these institutions, obtain brochures, host guest speakers, or obtain information from their school's guidance department.

Guest speakers from placement agencies or parents working in computer-related fields can be invited to provide students with information on trends in the local job markets. Field trips to local businesses and industries can also be used to provide students with information about the types of jobs that are currently available. The Student Guidance Information Service provides detailed job descriptions and information on career paths. Organizations such as the Data Processing Management Association, the Canadian Information Processing Society, and the Canadian Industrial Training Council can provide information on current national job trends.

Although work experience can be an integral part of any course and can provide students with opportunities to experience the world of work, because of the introductory nature of this course such experiences might have to be limited to observations of workers on the job.

Adaptations for use in lower grades. Units of instruction related to computer studies are sometimes included in programs for grades prior to Grade 10. For example, computer awareness or literacy units may be used in the elementary panel. Teachers who design such units are encouraged to plan them so that they emulate the balance of topics outlined in this section of the guideline. For example, a computer-awareness unit that addresses only programming would be inappropriate; a broader perspective is required.

Furthermore, some attempts at teaching young people an algorithmic language such as BASIC have met with mixed success. (Educational theory provides some clues to the cause.) Therefore, programming of this type should be done with the greatest care. Students who have the mental maturity or aptitude to do so should have the opportunity to program. Others should be quickly redirected so that they do not damage their self-image. These latter students are quite likely to be ready to pick up programming concepts in a few years. In general, the use of LOGO with very young children has been very successful.

Suggested Time Frame

The accompanying chart presents a suggestion for the percentage of class time to be spent on each of the broad areas outlined above for the three Introductory Computer Studies courses.

Introductory Computer Studies, Grade 10 (General)	Per Cent of Class Time
1. Using Application Programs on the Computer	20
2. Programming the Computer	15
3. Impact of Computers on Society	15
4. Computer Technology	15
5. Information Processing	15
6. Careers and Further Studies in Computing	5*
7. Computers and the Work Ethic	5*
8. Communication Skills	10*

Introductory Computer Studies, Grade 10 (Advanced)	Per Cent of Class Time
1. Operating the Computer	5
2. Programming the Computer	20
3. Impact of Microelectronic Technology on Society	20
4. Computer Electronics	20
5. Information Processing	20
6. Computer Science	5
7. Computer-Related Careers	5*
8. Communication Skills	5*

Introductory Computer Studies, Grade 10 (Basic)	
1. Using the Computer	20
2. Programming Concepts	10
3. Impact of Computers on Society	20
4. Computer Hardware	20
5. Using Computers in a Career	15
6. Employers and Computers	15*

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*The presentation of this topic should be integrated with that of the other topics in the course wherever possible.

Senior Division General-Level Courses

Computer Technology, Grade 11 (General)

Introduction

This course should provide a review and/or introduction to basic electronics concepts and component theory. Students should have the opportunity to learn suitable shop practices and techniques in order to efficiently and correctly diagnose problems in the repair, adjustment, and maintenance of a variety of microelectronic and electromechanical devices. It is intended that the student acquire a conceptual understanding of the electronics involved in computer logic, storage, and display in order to effectively carry out shop tasks.

Students taking this course are likely to be interested in technology. They require a practical, career-oriented curriculum that assists them to acquire both job-related skills and the knowledge and attitudes that they will require for a subsequent electronics course in Grade 12. The ultimate goal of these students could be further education at the college level or direct entry into the employment fields of general and digital electronics.

Students who have taken courses in electricity or electronics in Grades 9 or 10 before entering this course will likely progress at a faster rate and therefore obtain more from the course than will their classmates who have not taken such courses. As well, students would benefit from taking an electronics course concurrently with this course. A course in Introductory Computer Studies taken prior to this course would also be of considerable benefit. If students have not taken such a course, they should be provided with a sufficient introduction to programming to enable them to understand both what programming is and the relationship between the program and the hardware.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in nine broad areas.

1. *Evolution of technology*

A very brief historical background on the evolution of high-technology devices should enable students to understand:

a) the evolution of high technology and the importance of some of the milestones of this evolution;
b) that technological developments support the saying "Necessity is the mother of invention."

2. *Electronic representation of information*

Students should obtain a general understanding of the binary number system, which is used in computer circuitry, through the development of the following skills and understandings:

a) the ability to add and subtract in the binary system;
b) an understanding of how to relate electrical representation to binary 1 and 0;
c) a conceptual knowledge of data-communication terms such as *ASCII code* (American Standard Code for Information Interchange) and *baud rate.*

3. *Basic electronic circuits*

A review of or an introduction to basic electronics principles should enable students to learn how these principles are applied inside the computer. Students should develop an understanding of the following:

a) a resistance network;
b) the function of a diode;
c) the operation of a light-emitting diode;
d) transistor action;
e) the use of electrical measurement devices;
f) the function of TTL (transistor transistor logic) and CMOS (complementary metal oxide semiconductor) logic gates, and AND, OR, NOT, and EXCLUSIVE OR circuits.

4. *Applying circuit technology to computers*

Using practical shop experiences, students should develop an understanding of binary circuits and how circuits are combined to perform a computer function, including the following electronics principles:

a) the half adder and full adder;
b) the R-S flip-flop;
c) the implementation of R-S flip-flops using NOR gates;
d) the implementation of R-S flip-flops using NAND gates.

5. *Electronic output*
Students should become familiar with the use of bipolar and field-effect transistors in providing output by:

a) acquiring a conceptual understanding of the nature of bipolar and field-effect transistors;
b) using bipolar and field-effect transistors in multi-diode displays such as matrix and seven-segment.

6. *Logic circuits*
Students should increase their understanding of the use of logic in the computer and of the ways of developing logic circuits. This could be obtained through the following:

a) applying truth tables to multigate logic circuits;
b) developing specific circuits such as adders or subtracters from truth tables;
c) the use of alternate circuitry to carry out identical logic functions;
d) the development of truth tables from logic equations.

7. *Power supplies*
Students should examine the various types of power supply used in computers in order to understand what supplies are available and the suitable applications of each type of supply. They should be able to:

a) compare various power supplies that could be used in the computer;
b) demonstrate and explain the features of or the principles involved in battery-powered operation, alternating current, transformers, rectifier circuits, polarity of output, ripple filtering, and voltage regulators.

8. *Expectations of employers*
Students should be made aware of industry expectations and then given encouragement and guidance to make any necessary changes in their attitudes and work habits to accommodate the transition to the world of work. In this regard students should:

a) develop the work habits appropriate for a safe working environment within a shop or laboratory as well as at a customer's site;
b) be able to identify those technical tasks on which one should work quickly and efficiently and those on which one should work more slowly and carefully;
c) obtain practice in carrying out the two types of tasks outlined in (b);
d) understand and appreciate the relationship between the degree of effort applied to a shop-related task and the amount and/or quality of output that can be expected.

9. *Personal communication skills*
Students should be provided with opportunities to enhance and develop confidence in their communication skills by practising effective listening, speaking, reading, and writing so that they are able to:

a) listen carefully to and follow a short series of oral instructions (e.g., on the operation, maintenance, adjustment, and/or repair of devices);
b) read and follow a short list of instructions (e.g., those found in computer manuals);
c) orally describe to another student, or teach him/her to carry out, a task on a microcomputer or devices controlled by it;
d) prepare a short report, summary, or written series of instructions on a computer theme.

Computer Technology, Grade 12 (General)

Introduction

A single- or double-credit course may be designed to enable students interested in technology to continue the program initiated in Grade 11. In this way students can complete their secondary school program in a course that stresses the acquisition of the job-related skills, knowledge, and attitudes required for a subsequent high-technology program at a community college or for direct entry into employment in the field of general or digital electronics.

The course should emphasize the practical aspects of this field so that students become very competent in the specific job-related tasks that are normally carried out in a shop or on an installation site. Students should also be encouraged to develop work habits and attitudes towards work that are consistent with the expectations of employers. Since a major objective of computer technology courses is to prepare students for maintenance-related work, it would be an advantage to link these courses with those that include topics such as automotive electronics, controls, and other units of study that relate to process control.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in six broad areas.

1. *Applied logic*

Students should extend their understanding of Boolean logic and should apply it to computer circuitry so that they are able to understand:

a) the basic operations that are performed with Boolean expressions;
b) logic circuits that have been derived from given truth tables or vice versa;
c) how flip-flops are grouped into registers in order to perform tasks such as binary counting, shifting, and data transfer;
d) the difference among various types of flip-flops (e.g., D-type, J-K-type).

2. *Multivibrators*

Students should compare the functions of multivibrators in order to develop an understanding of the use of astable and monostable vibrators for timing.

3. *Encoding and timing*

Students should develop an understanding of the functions of the various types of encoders inside a computer and the importance of the timing of operations to computer operation. They should understand:

a) the coding, decoding, and multiplexing of data;
b) that complex processes consist of a sequence of individual events;
c) the nature and use of the codes used within the computer, such as BCD (Binary Coded Decimal), ASCII (American Standard Code for Information Interchange), and hexadecimal;
d) the concept and functions of clock cycles, including multiphase clock pulses;
e) timing diagrams.

4. *The computer as a system*

Students should develop an understanding of the computer as a system, one aspect of which involves the interrelationship of the microprocessor with memory. In developing this understanding, students should be able to:

a) use circuits to carry out a practical, clearly defined task;
b) obtain a global understanding of computer architecture and the computer's components;
c) understand the function of an instruction set that is used by a microprocessor and write sample instructions that would form part of an instruction set;
d) understand the interrelationship of the processing unit with both memory and input/output devices;
e) compare some storage technologies (e.g., bubble memory, core, solid state);
f) distinguish the differences in the principles underlying a variety of readouts, such as the cathode-ray tube (CRT), the light-emitting diode (LED), and the liquid-crystal display (LCD);
g) identify the intercommunication that takes place among the various components of the computer;
h) use bus structures in a variety of typical applications;
i) outline the need for bus standards and the loading considerations for buses;
j) describe the various types of input-output operations, DMA (direct memory access), and interrupt functions.

5. *Expectations of employers*

Students should become aware of the expectations of employers in business and industry and be given encouragement and guidance to make any necessary changes in their attitudes and work habits to accommodate the transition to the world of work. This should include a recognition of the importance of safe shop practices and the need for good "housekeeping".

6. *Personal communication skills*

Students should be provided with opportunities to enhance and develop confidence in their personal communication skills by practising effective listening, speaking, reading, and writing so that they are able to:

a) listen to and follow a series of oral instructions in a shop environment;
b) read and follow the instructions in a typical manual used by technicians;
c) orally describe to another student, or teach him/her to carry out, a specific, shop-oriented task;
d) prepare a short, written report or summary of material found in a typical service manual.

Teaching Suggestions for Computer Technology, Grades 11 and 12 (General)

While the following teaching suggestions are presented by grade for convenience, it should be noted that many Grade 11 suggestions are applicable to Grade 12 and vice versa.

Grade 11

For many students this will be their first contact with the world of digital electronics. Consequently, the basics should be emphasized and as much practical work as possible should be included in the course. Once students become familiar with basic circuit and component theory they can begin simple projects. The sooner this is done the better, since nothing creates more interest in electronics than simple, practical projects. There are many electronics magazines and project books readily available that supply all the details necessary for the construction of many interesting and inexpensive devices.

The course theory should be reinforced through a set of comprehensive experiments using experimentation boards in the lab. In most cases these experiments can be done with a minimum of test equipment, since most digital conditions can be indicated by LEDs. Students can use simple experiments set up on these boards to determine the characteristics of discrete components and integrated circuits. When students see how flexible these components are, they will be motivated to explore more advanced applications of the circuits being studied. Often they will see applications that can be demonstrated in science-fair projects or applied to practical devices. Note that it is important for students to experiment with up-to-date electronic components.

Teachers are encouraged to use films and other audio-visual materials throughout the course, and especially in teaching the introduction or overview. The Fast Forward series by TVOntario is an excellent example of some of the materials that are currently available. Computer programs such as The Learning Company's *Rocky's Boots* could be used in the construction and testing of logic circuits.

Library research projects should also be part of the work in the introductory section of the course. Student presentations through seminars, essays, or posters are effective ways of covering the material dealing with the history of automation and modern computers.

Teachers are also encouraged to make an effort to relate specific circuits to the overall system. Often students study circuits in isolation and lose sight of their application in an operating system. A classroom chart showing, for example, the main blocks in a computer system will serve as a constant reference for the students. In this way they can relate the specific items being studied to the overall picture. As well, examples of situations in which logic circuits or switching circuits can be applied should be used to illustrate industrial applications.

In order to maintain student interest, a reasonable balance should be established between theory, experiments, and project work. Generally speaking, about 50 per cent of classroom time is devoted to experiments and project work. Many students will continue their project work outside of class time, often forming electronics clubs and doing project work at home.

Since these courses emphasize a systems approach to circuit blocks, it is recommended that a project and laboratory approach be taken. For this reason it is useful to equip the laboratory with a suitable number of commercial logic trainers and/or microprocessor trainers.

Laboratory circuits can be constructed from perforated boards, wiring boards (breadboard, Protoboard, etc.), and printed circuit boards. The latter can be prepared photographically, or with masking tape, paint, and ink. Switches can be used to generate the two-state logic levels for illustrating gating principles. Gating circuits can be constructed either from discrete components or integrated circuits.

Students can design and build a relatively simple mechanical calculating device using available materials. However, when topics for which hardware construction projects are not appropriate are dealt with, the use of work sheets, chalkboard drills in small groups, individual assignments, and short daily drills are effective.

Grade 12

The Grade 12 course lends itself to a wide range of practical exercises. The study of counters, memory circuits, microprocessors, decoders, and interfaces provides many opportunities for practical projects. The following are some components that could create a focus for possible projects:

- decode counter
- up-down counter
- binary-to-decimal decoder
- hexadecimal decoder
- keyboard encoder
- clock circuit
- timer circuit
- memory circuits
- seven-segment display
- interface adapter
- D to A adapter
- A to D adapter

There are many electronics magazines and project books on the market that outline projects in these areas. Students should be encouraged to select projects that involve counters, memory, decoders, and even a microprocessor.

This course should focus on the microprocessor unit (MPU). Students should develop a good understanding of microprocessor architecture so that they will understand the support chips that connect to it. There are a number of microprocessor kits on the market that can be used to teach students the operating codes for a particular MPU and to familiarize them with basic interfacing techniques. Interface adapters are also available for most of the microcomputers used in the schools. These adapters allow students to use the computer to control other devices. Conversely, data from connecting devices can be delivered as an input, for processing by the computer.

A major part of the course should be experiments. Students can undertake a variety of fairly complex experiments with a minimum of apparatus. Experimentation boards allow for the quick assembly of circuits involving both discrete and integrated components. Teachers are encouraged to use a well-designed set of experiments to illustrate the characteristics of all of the basic circuits covered in the course.

The course should reflect a reasonable balance of theory, experiments, and project work. Normally about 50 per cent of the class time should be spent in project work and experiments. There are many activities that might be planned for the Grade 12 course. For example, students can be asked to:

- construct a binary counter using type D flip-flops;
- connect a seven-segment decoder and readout to indicate the state of a binary counter or register;
- construct a timer using the 555 integrated circuit or its equivalent;
- construct a hexadecimal encoder using simple pushbutton-type keys and a seven-segment display;
- construct a free-running clock circuit.

Where a microprocessor or minicomputer is available, students can construct basic interface circuits and prepare programs for them. Where time and resources permit, students can design and construct a microprocessor system.

Suggested Time Frame

The accompanying chart presents a suggestion for the percentage of class time to be spent on each of the broad areas outlined above for the two courses. Note that at least 50 per cent of the class time should involve shop or laboratory activity.

Computer Technology, Grade 11 (General)	**Per Cent of Class Time**
1. Evolution of Technology	5
2. Electronic Representation of Information	10
3. Basic Electronic Circuits	20
4. Applying Circuit Technology to Computers	20
5. Electronic Output	10
6. Logic Circuits	15
7. Power Supplies	10
8. Expectations of Employers	5*
9. Personal Communication Skills	5*

Computer Technology, Grade 12 (General)	
1. Applied Logic	20
2. Multivibrators	10
3. Encoding and Timing	25
4. The Computer as a System	25
5. Expectations of Employers	10*
6. Personal Communication Skills	10*

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*The presentation of this topic should be integrated with that of the other topics in the course wherever possible.

Data Processing Concepts, Grade 11 (General)

Introduction

This course should provide students with a brief introduction to simple programming concepts. Other computer concepts, especially as they relate to business activities, should be explored to provide students with additional background. The major emphasis of the course, however, should be on the operation of available computers to carry out business functions.

The data processing concepts and techniques presented in the course will provide students with the background they need to relate specific occupations that might interest them to the broad field of information processing, as well as to help them make intelligent decisions when faced with problems in their courses or work in the future.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in ten broad areas.

1. *Computers in business*

Students should obtain a broad overview of the use of computers in business and consider the impact that such use might have on people and profits. In doing so they should acquire the following skills and understandings:

a) the ability to use a preprogrammed computer to illustrate simple computer applications in business;
b) a knowledge of the evolution of information processing devices in society in general and in business in particular;
c) an understanding of how the business computer could be considered an information processing tool;
d) an understanding of how effective use of the computer could increase profits;
e) an understanding of the ergonomic implications of computers and video-display terminals;
f) the ability to distinguish among a number of systems commonly found in business (information flow, programming, hardware systems);
g) a knowledge of current changes taking place in the world of work that involve new job skills, the need for retraining, and other trends and opportunities.

2. *Programming the computer*

Students should be provided with an introduction to or a review of fundamental programming concepts and have the opportunity to extend their knowledge in this area sufficiently *to satisfy their individual needs or interests.* They should acquire the ability to:

a) on specific written direction, list and alter one or two instructions to correct or enhance an existing applications program;
b) insert a program module into an existing program in order to read through a file and obtain a simple report on one or two fields contained in the file;
c) identify or write program modules to illustrate additional functions of the computer that could be used in the solution of a problem.

3. *Using application programs*

Students should gain experience in using industrial-standard application programs or special programs designed to help them learn about computer-based business applications. In so doing they should acquire the ability to:

a) classify types of data and enter the appropriate data into the computer on direction as in a journalizing application;
b) enter any necessary variables (e.g., the date) and produce financial statements from information contained in a storage file;
c) organize payroll information from raw data and enter suitable data into the computer on direction;
d) use an inventory program to manage an inventory file;
e) use a limited number of programs that may be found in available application utility programs (e.g., electronic spread sheets, word processing, file managers, data-base managers).

4. *The computer and its devices*

Students should acquire an understanding of the functions of the computer and those of its peripheral devices that are commonly used in business. They should be able to:

a) identify the major components of a computer system and provide a brief description of the function of each;
b) describe in general terms what occurs inside a computer, using a schematic diagram that has been provided;

c) clearly explain the relationship between the program and the hardware;
d) identify and describe the unique features of a variety of (i) input devices, including point-of-sale terminals, and (ii) output devices;
e) describe in general terms the electromagnetic principles of disc and tape devices and the organization of their media.

5. *Hardware maintenance*
Students should learn and practise the proper care and maintenance of the computer and its peripheral devices. They should be able to:

a) describe situations that might lead to the damage of the computer or its peripheral devices;
b) illustrate routine care and maintenance procedures;
c) demonstrate proper disc- and tape-handling techniques;
d) where facilities exist, carry out suitable activities to respond to error and/or condition signals on devices (resetting breakers, mounting and dismounting media, etc.).

6. *Handling information*
Students should obtain an overview of the ways in which information is processed in business so that they are able to:

a) describe the flow of information (i) in a particular business and (ii) among businesses;
b) carry out the tasks of recording, classifying, and sorting information;
c) outline reasons why data must be verified and/or the need for error traps or data editing within a program;
d) describe the organization of electronically stored files and illustrate how a variety of information can be produced from such files;
e) describe or illustrate the principles of data-base management.

7. *Higher-level operation of a computer*
Where facilities exist, students should obtain practical experience in the operation of computer consoles and the underlying principles involved in that operation. Students should be able to:

a) illustrate the ways in which information may be represented in storage;
b) understand the need for instruction sets and be able to differentiate among types of instruction (arithmetic, data transfer, input-output, branching);
c) handle error conditions, set up the system, carry out recovery routines, and interpret console messages.

8. *Careers and further studies*
It is important that students become aware of the career applications of the skills and knowledge that they are obtaining in this course and of further courses or training offered in data processing. This should include:

a) the ways in which student skills and knowledge might be used in part-time employment or in a future course;
b) the variety of careers in which computer skills could be used;
c) courses and programs that could be taken to further develop student aptitude, interests, skills, and knowledge in the dynamic field of computing.

9. *Personal communication skills*
Students should be provided with opportunities to enhance and develop confidence in their communication skills so that they are able to:

a) listen carefully to and follow oral instructions on the operation of hardware;
b) orally describe some aspect of computers in business or provide oral instructions to peers on how to operate or carry out preventive maintenance on peripherals;
c) read and interpret material written about devices or data-handling techniques;
d) prepare short lists of instructions for people to follow, such as an operations manual;
e) describe or illustrate the flow of information, people, or products in a business setting;
f) prepare job descriptions in, or condense paragraphs into, point form.

10. *Expectations of employers*
Students should be made aware of the expectations of the business community so that they may modify their attitudes and work habits in light of these expectations. In this regard students should:

a) appreciate the need to be sufficiently productive in all aspects of computer operation to make it worthwhile for an employer to continue their employment;
b) be able to identify the ways in which certain attitudes, habits, and actions reduce productivity in a data processing centre or at a work station.

Data Processing Applications, Grade 12 (General)

Introduction

This course should provide students who have the necessary background with the opportunities to refine their ability to use industry-standard computer-application programs. Students should become competent at using a small business computer system or, where facilities exist, at operating a large mainframe computer and its peripheral equipment.

The course is designed to help students acquire the necessary computer skills for direct job entry, where they will likely be carrying out the diverse tasks involved in entering information into and operating a small business system. For this reason a co-operative education component would ideally be a part of the course. This course will also provide excellent background for certain community college programs.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in eleven broad areas.

1. *Using data in a computer*

Students should gain practice in classifying data and entering appropriate data for processing by the computer. This includes the ability to:

a) classify a variety of accounting data;
b) interpret the requirements of a program and enter the appropriate data;
c) interpret and take action on (i) expected output and (ii) errors or exception messages.

2. *Competency at operating the computer*

It is expected that students will become competent at using a variety of programs commonly used in business and be able to:

a) use industry-standard general-ledger programs, financial-reporting packages, payroll packages, and inventory packages;
b) experience using all, and develop expertise in using at least one of, the following utilities: electronic spread sheets, word processors, data bases or file managers;
c) experience using one non-business application, such as a technical data base.

3. *Documentation and its uses*

Students should learn the importance of good documentation and how it may be used to advantage. They should be able to:

a) read a manual and learn to use a function of the program package that had not been used before;
b) alter programs with the assistance of specific written instructions by listing a program and, with the assistance of a documentation updating sheet,
   (i) inserting one or more new instructions and
   (ii) altering one or more instructions.

4. *Hardware maintenance*

Students should be provided with a review or an overview of how to organize and care for the hardware and its storage media so that they are able to:

a) describe or refer to illustrations to explain ergonomic issues and concerns;
b) apply ergonomic principles to their own work stations;
c) carry out routine cleaning of the outside of the hardware;
d) clean read-write heads;
e) change a ribbon on the printer;
f) identify a fault of some type and recognize the need to call for qualified service personnel;
g) properly handle and store tapes and discs, avoiding actions that may damage the media or erase what is stored.

5. *The computer's interface with business information*

Students should be provided with opportunities to extend their knowledge of business organization and structure to encompass the following:

a) how access to a file can be obtained by more than one person using more than one specific program;
b) the channels through which information flows within a business and among businesses;
c) important current business practices that involve computers (distributed processing, time sharing, data banks, networks, classes of computers, electronic transfer of information, electronic transfer of funds, etc.).

6. *Business codes*

Students should become aware of and be able to identify a variety of codes used in the operation of the computer to identify and process data stored in it; they should be able to:

a) identify messages, codes, and signals generated by a computer;
b) understand, in general terms, the types of codes used (i) to store information in a computer and (ii) for communicating information electronically;
c) identify a number of ways in which products are coded.

7. *Managing data files*

Where facilities are available and they have acquired the appropriate programming and operating background, students should be provided with practical experiences in managing files on a large computer system so that they are able to:

a) combine and edit data stored on file;
b) create files;
c) sort and merge files;
d) create file menus;
e) verify the processing of data using a variety of techniques;
f) update files;
g) generate meaningful reports;
h) establish back-up facilities;
i) use a variety of internal searches and sorts;
j) develop and use an audit trail.

8. *People are part of an effective system*

Students should become aware of the importance of people within a system, especially in identifying and affecting changes needed within the system. They should acquire the ability to:

a) seek out and identify a flow in a system (e.g., people flow, textbook flow, product flow, information flow);
b) identify either problems to be overcome or improvements to be made;
c) create ways of solving the problems or making the improvements;
d) either implement the changes or simulate the implementation;
e) identify issues that focus on interpersonal relationships and recommend ways of dealing with these issues;
f) relate what has been learned in the case study to possible situations in which they may become involved in the business world.

9. *Expectations of employers*

Students should be made aware of the expectations of the business community so that they may evaluate their own attitudes and work habits in light of these expectations. They should be able to:

a) explain the need for productive workers in order for an enterprise to remain solvent;
b) identify ways in which certain personal habits and attitudes may diminish productivity;
c) research the expectations that a number of the community's business establishments have for their workers and identify commonalities.

10. *Work experience*

Students should be provided with opportunities to gain practical experience in the workplace (e.g., using a computer or a word processor in a business establishment) so that they can identify:

a) the differences between such experience and traditional school experiences;
b) personal weaknesses that could be corrected prior to obtaining full-time employment (e.g., by the acquisition of additional knowledge and/or skills, changes in work habits, attitudinal changes).

11. *Personal communication skills*

Students should be provided with opportunities to enhance and develop confidence in their communication skills so that they are able to:

a) listen to and interpret computer operating instructions;
b) after some organizational preparation, orally report on material related to the programming, operating, or maintenance of a computer or its peripherals, or outline an approach to solving a problem;
c) read and interpret for others material relating to information processing and its issues;
d) write summaries or reports on matters relating to the computer in a clear, effective style.

Teaching Suggestions for Data Processing Concepts, Grade 11 (General), and Data Processing Applications, Grade 12 (General)

These courses should be designed for those students who require more knowledge and skills than are supplied in the Introductory Computer Studies course. As the emphasis or theme of the courses is the use of computers in business, business data processing concepts and procedures should form a significant part of the courses. Some programming could be introduced in the Grade 11 course to reinforce and extend the programming concepts learned in the Introductory Computer Studies course. These programming activities can also be used to identify students who have an aptitude for additional instruction in programming and who might benefit from being transferred to Data Processing Techniques, Grade 11 (Advanced). It is the responsibility of the teacher to sense the point at which a student has had sufficient programming to satisfy his/her needs. The teaching of a particular programming language is not to be the focal point of this course. The advanced-level course, Data Processing Techniques, is designed for students who have an interest in and aptitude for programming. Students selecting this course have decided that they do not have an aptitude for programming or sufficient interest in learning such a skill. Their time will be spent most profitably in mastering the many interesting and challenging non-programming skills and in learning concepts outlined as the content of the general course.

Students should have the opportunity to acquire considerable practice in using the computer through the completion of assignments involving the preprogrammed general-ledger and other business-related program packages. Teachers should demonstrate the proper techniques for handling media at the outset to avoid the possibility of damage to computer equipment.

An important objective of these courses is to increase student awareness of the expectations of business and industry. For this reason opportunities for students to practise good work habits should be built into the courses. These should include coming to class on time, making efficient use of class time, completing assignments within the time allotted, and identifying the next task to be done without specific directions from the teacher unless advised to the contrary.

Some students quickly obtain a global perspective of a task and use that perspective to integrate individual components as they are learned. In such cases teachers need only provide an overview of the task to be learned and then teach the concepts or component skills, often just once. Other students, however, learn best by mastering the components of a task one at a time. Such students only begin to really appreciate or understand the total task when the last few components have been mastered. The teacher should choose an appropriate mix of these two approaches.

While practical skills usually require a certain amount of repetition, some students require much more practice than do others. If student momentum is to be maintained, assignments should be varied, and sufficient motivation and encouragement should be provided so that students complete the practice they require to master each skill.

Students also need time to internalize what they are learning. To help them accomplish this, teachers might find it advisable to divide tasks into small stages. For example, students should clearly understand what is required at each stage of operation of computer hardware and software before being given the time to practise. As they learn and master additional components, the students will increasingly be able to appreciate the interrelationship of the components. It cannot be too strongly stressed, however, that the initial steps in learning a skill should be introduced with clarity and patience.

Repetition and drill are useful for a very limited range of factual learning and skill acquisition. For example, interesting and challenging drill and practice routines could be used where it is necessary or ultimately most efficient to memorize operation procedures or the parts of a device. However, this type of activity is not a good way of learning concepts.

The teaching of concepts will vary with the ability of students to internalize their new learning. For students who learn best by absorbing new material in increments, it might be best to introduce a concept and then form small groups of students to work on a task directly related to the concept. For example, the concept of the relationship between cost and benefit could be explained by the teacher. Groups could then be formed to identify the costs and benefits involved in a specific project. The dialogue that takes place within each small group of students might prove to be much more effective than the frequent repetition of the concept by the teacher. In addition, group work on case studies or specific tasks would simulate the popular team approach used in business.

Students should spend most of their time doing practical tasks. This could involve their spending considerable amounts of time working with the computer. Where seatwork is considered desirable, that work should use materials such as business forms to simulate business activities and practices.

An emphasis should be placed on having students experience situations that they might encounter in the workplace. Such situations can be simulated in exercises using the computer. Where the handling of files is a major component of the course, teachers can create test-data sets from which students can make assessments of system accuracy. Similarly, teachers can create files for merging and editing from which student responses can be predicted. While sorting, searching, and auditing techniques are important, they need not be studied in depth.

Many of the characteristics of secondary storage can be explored through problems designed around dump utilities, where files can be examined. Short programs can be developed to change blocking factors. File names can be changed so that students address the problem created when file names, as defined by the program, are not in agreement with storage.

Students should be allowed to explore systems utilities to develop an understanding of how these can help them carry out their duties. System security and integrity checks should be discussed with a view to developing positive values such as honesty, responsibility, and professional conduct.

Suggested Time Frame

The accompanying chart presents a suggestion for the percentage of class time to be spent on each of the broad areas outlined above for these two courses.

Data Processing Concepts, Grade 11 (General)	**Per Cent of Class Time**
1. Computers in Business	5
2. Programming the Computer	5
3. Using Application Programs	35
4. The Computer and Its Devices	10
5. Hardware Maintenance	5
6. Handling Information	20
7. Higher-Level Operation of a Computer	5*
8. Careers and Further Studies	5†
9. Personal Communication Skills	5†
10. Expectations of Employers	5†

Data Processing Applications, Grade 12 (General)	**Per Cent of Class Time**
1. Using Data in a Computer	5
2. Competency at Operating the Computer	40
3. Documentation and Its Uses	3
4. Hardware Maintenance	5
5. The Computer's Interface With Business Information	25
6. Business Codes	2
7. Managing Data Files	2*
8. People Are Part of an Effective System	8
9. Expectations of Employers	3†
10. Work Experience	5
11. Personal Communication Skills	2†

*This topic should be expanded significantly if suitable hardware is available.

†The presentation of this topic should be integrated with that of the topics in the other course wherever possible.

Senior Division Advanced-Level Courses

Computer Science and Technology, Grade 11 (Advanced)

Introduction

This course should be designed for those students who have an interest in computing and wish to learn about the computer in some depth. These students should have opportunities to develop programming skills and to apply those skills to solving diverse types of problems. The internal organization of the computer should be explored, with emphasis placed on how information is represented and processed within the computer and its related equipment. Logic theory will form the basis for carrying out introductory experiments in electronics using simple circuit boards.

This course will challenge those students who have an interest in the more technical side of computing, including programming and the computer's internal architecture. It should provide a sound background for advanced courses in computer technology or computer science.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in eight broad areas.

1. *Introduction to programming*

Students should master and use the major programming elements in a high-level language, including the following understandings and skills:

a) an overview of the computer and its parts;
b) the need for an organized approach to solving a problem;
c) a mastery of the major functions of a high-level language, including (i) instructions such as input and output, assignment, decisions, repeat structures, unconditional branch, and built-in functions (a few samples), and (ii) rules for variable types, arrays, and subroutine structures.

2. *Programming techniques*

Students should learn and practise programming techniques within a structured programming framework, including the ability to:

a) use counters, loops, decision structures, error traps, and exit-from-module routines (using counters, dummy data, or changes in data conditions);
b) use a suitable style of programming, employing the three basic programming structures (sequence, selection, and repetition) within modules, indicating the proper use of imbedded comments and descriptive variable names, indentation, and spacing for clarity;
c) write programs composed of a main logic module and submodules linked hierarchically to it (each module having one point of entry and one exit);
d) use effectively suitable methods of testing and debugging, including manual testing of the solution; differentiating between error types such as compile-time errors versus execution-time errors or syntax errors versus logical errors; interpreting types of diagnostic messages; using appropriate test data to test all possible logical conditions in a program; using traces as well as pencil and paper in order to test the logic of a program; using debugging output statements to indicate position markers within the program and output intermediate results; using trace utilities, storage dumps, or cross-reference tables to assist in debugging; and practising "play computer" using pencil and paper in order to test the logic of a program;
e) use effectively suitable documentation techniques, including defining global and local variables, identifying variable types, showing the interrelationships of modules through the use of a diagram, delineating the input/output formats, providing a program description in straightforward sentences, and expressing the limitations of the program.

3. *Problem-solving*

Students should develop problem-solving skills using applications derived from a wide range of disciplines (theoretical and applied) so that they are able to:

a) create solutions to assigned problems, identifying the input, the output, and the processing required to achieve the output;
b) use the "top down" approach to the solution of a problem;
c) demonstrate the flow of the solution by creating a logic representation as: (i) a planning tool and (ii) a documentation component;
d) write the necessary program instructions to convert the algorithm into a program using a high-level language and proper programming techniques;
e) apply testing and debugging techniques to verify the correct solution of the problem.

4. *Impact of computer technology*
Students should develop an understanding of and appreciation for the effects of computer technology on society in general and on themselves in particular. In doing so they should:

a) become aware of and be able to evaluate recent developments in hardware and software, and applications in business, industry, science, and related research;
b) become aware of the potential jobs, and requirements for them, in the computer field by investigating job descriptions, salaries, working conditions, and educational requirements.
c) explore computer-related issues, such as threats to privacy, employment displacement, and computer crime.

5. *Inside the computer*
Students should develop an understanding of the interrelationships among the basic components in a computer system (e.g., the microprocessor, storage, input and output devices) so that they are able to:

a) use the correct name and describe the function of the various components within the computer (e.g., microprocessor, ALU, ROM, RAM, bus);
b) describe the flow of instructions and data within a computer;
c) identify the major characteristics and functions of storage devices or modes (tape, disc, bubble, transistor, core).

6. *Elements of computer electronics*
Students should develop a conceptual understanding of the basic logic circuits, including the ability to:

a) illustrate and describe the functions of logic gates (AND, OR, NOT, NAND, NOR, XOR);
b) contrast discrete gates with combinations of gates on chips;
c) identify the benefits and function of large-scale integration;
d) develop a truth table and relate it to sample logic gates.

7. *Applied logic*
Students should acquire an understanding of how combinations of gates carry out a task, including the ability to:

a) describe and outline the applications of a half adder, a full adder, binary subtraction circuits, registers using NOR gates, and registers using NAND gates;
b) describe the need for temporary or auxiliary storage;
c) apply to computer circuitry basic Boolean algebra concepts (including logical expressions and symbols, Boolean postulates and theorems, the interpretations of Boolean expressions) and use Boolean algebra to simplify logic circuits;
d) use Karnaugh maps and logic simplification techniques.

8. *Use of circuits to create information in code*
Students should learn a variety of ways in which data may be represented electronically in the computer. They should be able to:

a) draw schematic diagrams of elementary circuits and construct such circuits using batteries, switches, and light-emitting diodes in order to (i) trace current paths in a circuit and (ii) relate on and off states and high and low levels of current to binary ones and zeros;
b) perform binary operations on paper, including (i) binary addition, (ii) "ones and twos complement" of binary quantity, (iii) binary subtraction using twos complement, and (iv) the AND, OR, and EXCLUSIVE OR operation between two binary quantities;
c) segment and name binary quantities in order to differentiate among the terms *bit, nibble, byte,* and *word;*
d) express how binary data are transferred in both serial and parallel form and describe what is meant by *baud rate;*
e) distinguish between binary data in various forms such as ASCII and BCD codes;
f) express binary data in alternate notational forms such as octal and hexadecimal numbers.

Computer Science, Grade 12 (Advanced)

Introduction

This course should appeal to students who have demonstrated an aptitude for programming and problem-solving. It should provide them with opportunities to develop and extend their computing skills and knowledge. By means of programming assignments based on diverse, mainly practical applications, students should become skilful at using most of the available programming language constructs.

As they acquire more advanced computer science concepts, students will be better able to understand the relationship of the program to the hardware. The resulting base of knowledge and skills should provide them with the ability to identify unique approaches to improving current applications or, perhaps more challenging, to identify in an environment situations or problems for which unique computer applications should be developed. This would involve the students in identifying complex tasks and developing comprehensive step-by-step approaches to accomplishing the tasks, including the synthesizing of technology, software, and human resources.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in nine broad areas.

1. *Advanced programming*

Students should learn advanced programming techniques so that they may extend their skills by using most of the constructs of the available language. They should be able to:

a) manipulate character strings, using the built-in functions of the language;
b) use, in program solutions, the subprogram structures available in the language;
c) identify the applications for and effectively use the user-defined function capabilities of the language;
d) effectively use array structures, both single- and multiple-dimensioned;
e) effectively use the various types of variable available to the programmer and state how the choice of type will affect the modes of processing, speed of execution, and the memory used.

2. *Planning logically*

Students should develop and implement reasonably sophisticated algorithms. They should be able to:

a) write programs that sort data into numerical or alphabetic order;
b) demonstrate a conceptual knowledge of, and the ability to contrast, a variety of sorting techniques;
c) contrast sequential and binary searches;
d) write programs to merge two or more previously sorted lists;
e) understand the techniques involved in creating a random-number generator;
f) use appropriate techniques to create and access (i) a sequential file, (ii) a random-access file, (iii) linked lists that employ indices, pointers, or keys, and (iv) tree structures.

3. *Developing diverse applications*

Students should expand their knowledge of the diverse applications of the computer by using advanced programming techniques to apply practical solutions to a wide variety of areas. They should be involved in planning and writing well-structured, well-styled, and well-documented programs that use each* of the following classes of applications:

a) textual manipulation, such as text editors, language translators, alphabetic sorting, and word processing;
b) three-dimensional graphics and animation, graphing, removing "hidden lines" from overlapping figures, shading interiors of figures;
c) the solution of problems that must be done by interactive methods either because no algebraic solution can be found or because the algebraic solution is known to exist but is not easily obtainable, e.g., area under curves, roots of equations, linear programming, and optimization of design;
d) simulations, such as games of chance, random processes, queues, and Monte Carlo methods;
e) statistics, set-up processes for computation of mean, median, mode, variance, standard deviation, correlation co-efficient, chi-square test, and normal and other distributions (statistical theories should not be developed);
f) additional concepts as identified as a result of developing technology.

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*See the teaching suggestions following this course outline.

4. *Impact of computer science*
The applied programming being done in class should be related to the impact that such applications are having on society so that students are able to:

a) identify and either discuss or write a formal essay on at least three issues related to the social implications of computer applications;
b) identify and discuss in general terms the ways in which computers could be programmed to assist special groups of people, such as exceptional students, the handicapped, the aged, and those who are socio-economically disadvantaged;
c) design hardware and/or programs for and then actually implement an application identified in (b) above.

5. *Converting program code*
Students should obtain a conceptual understanding of the major characteristics of various operating-system modules and learn the terms used in describing a system so that they are able to:

a) contrast the characteristics of system software such as compilers, interpreters, emulators, and translators;
b) describe the operation of a multiple-pass compiler;
c) correctly use such terms as *object/source code, stacking, queue time sharing, interactive system, operating system, network, linking and loading, batch processing, interactive programming,* and *data base.*

6. *Computer architecture*
Students should acquire a thorough understanding of the internal organization of the computer so that they can synthesize the following:

a) the various addressing techniques (direct, indirect, relative, immediate);
b) memory organization (paging, bank switching);
c) the flow of data in a computer bus system and the interrelationships among the various components (microprocessor, memory, and input-output devices) made possible by the bus system.

7. *Low-level languages*
Students should learn and use a small subset of the instructions of a real low-level language to solve simple problems, including the following:

a) loading and storing accumulators, incrementing registers, etc.;
b) using logic operations such as branching on conditions;
c) using arithmetic operations;
d) using various addressing techniques.

8. *Careers and further studies*
Students should become aware of the career applications of the skills and knowledge that they are obtaining in this course and of further courses or training offered in computer science. This should include:

a) the ways in which student skills and knowledge might be used in part-time employment or in a future course in co-operative education;
b) the variety of careers in which computer skills could be used;
c) courses and programs that could be taken to further develop student aptitude, interests, skills, and knowledge in the dynamic field of computing.

9. *Personal communication skills*
Students should be provided with opportunities to enhance and develop confidence in their communication skills by practising effective communication so that they are able to:

a) listen carefully and respond critically to the computer-related presentations by other students, the teacher, through films, etc.;
b) read and interpret orally for others a range of materials (technical manuals, descriptions of sociological issues, etc.);
c) research and prepare formal reports or essays on topics and issues related to computers.

Teaching Suggestions for Computer Science and Technology, Grade 11 (Advanced), and Computer Science, Grade 12 (Advanced)

Problem assignments in programming should be carefully planned so that they allow students to practise each of the elements of the programming concepts. Most students who have the potential for success in this course will be able to absorb much of the language very quickly during the first part of the course. This will provide them with a variety of tools to use in the solution of the diverse, practical problem assignments. These varied assignments, not the teaching of the language nor miniature assignments used to apply language concepts, should take up the major part of the time set aside for problem-solving and developing sound programming style.

However, even when the learning of the language is carried out very early in the course, additional program functions and features can be periodically introduced, as needed, throughout the course. The main focus should remain, however, on the multi-faceted tasks involved in developing complete solutions to practical problems, rather than on newly introduced language functions.

The intent of the application part of this course is to expand the students' horizons by having them develop solutions to practical programming assignments from as great a variety of disciplines as possible. (Necessary mathematical theory should be introduced only as a means to solving a practical problem.) Teachers are encouraged to share their methods for accomplishing this with their colleagues.

The development of the topic on the impact of computer technology on society could be enhanced by classroom visits by computer professionals and other guest speakers and the use of field trips, films, and videotapes. Newspaper articles and professional journals could be used to provide current information and material for scrapbooks or bulletin-board displays.

Electronics students could design and construct inexpensive projects with the aid of the electronics or electricity teacher. These projects could be used for hands-on experiments so that students can better understand some of the electronics concepts that are covered in the course.

Grade 11

Since a major part of the Grade 11 course is devoted to developing application programs, a project approach should be taken. Initially, students can do easy programs either individually or with the help of their peers. When students are ready for more complex programs, a task-assignment technique could be developed. Through group projects students will gain experience in planning, dividing tasks into modules, distributing subassignments, and working together at the integration, testing, and debugging of the program.

Because of the nature of this course, some students will undoubtedly be exposed to areas that are not mastered by others in the class, including, in some cases, even the teacher. An open discussion of this possibility will encourage a healthy sharing of individual student discoveries.

Students should develop a clear understanding of what is meant by modular hierarchical programming — often called "structured" or "top-down" programming. Initial programs should be written using this approach to develop and reinforce efficient design. Students should be aware of the ways in which a well-designed program can be effectively tested, debugged, and ultimately enhanced. (See also the objectives and teaching suggestions for Data Processing Techniques, Grade 11 [Advanced] below.)

Recent research suggests that there is no advantage to developing a logic representation such as a flow chart or structure diagram prior to coding. Students creating a modular program on an interactive computer such as a microcomputer usually do equally well without a logic diagram as those who have one. However, it is generally expected today that good documentation will include a logic-representation diagram. Perhaps, in time, a well-structured and annotated listing will provide all of the information normally conveyed by some logic representation. It should be noted that most teachers find the traditional flowchart unsuitable for representing the logic of a structured program.

The suggested time lines for this course call for about 30 per cent of the course time to be spent on the necessary mathematical theory of, and introduction to, computer technology and architecture. This requires a restructuring of the traditional programming course. If students are to obtain the intended insights into the hardware aspects of computers, they must be presented with a well-planned series of experiments. These experiments can be presented simply and efficiently through the use of industrial components and experimentation boards. These projects are quick to assemble and are inexpensive.

A full-scale lab is unnecessary for this course. The required experiments can be done without expensive test equipment, as most digital conditions can be indicated by LEDs. This equipment does not require expensive or bulky power supplies. All of the hardware devices in this course can be powered by a small 6 V lantern battery. Experiments can be designed that make expensive test apparatus unnecessary.

Students can very quickly become familiar with circuits that process, decode, and display both binary and decimal numbers. They can begin with very simple circuits and discrete components and gradually progress to more complex integrated applications.

The hardware topics and their associated experiments generate ideas for a range of electronics projects. Most electronics magazines and project books provide construction details for dozens of useful digital devices. Students should be encouraged to do project work to complement their studies in this course. Teachers having the necessary background and experience might consider assigning suitable projects as part of the course requirements.

Grade 12

Objective (3) of Computer Science, Grade 12 (Advanced) requires the development of diverse applications programs which involve a considerable amount of programming time on the computer. Mathematical and computer science theory should be introduced only as a means of developing solutions to practical problems. It is not expected that all students will write a comprehensive program for each classification listed in the objectives. Certainly each student is expected to produce at least one comprehensive program of some significance. Time could be saved by having students program only parts of programs, or by having them address the essence of the application. Some of the applications could be fully and formally completed using a team approach in which each student would be involved in planning and documenting the whole program but would write the code for only one component.

Although hypothetical assembly languages exist, teachers are encouraged to have their students work with elements of an existing assembly language or a simulator of an actual language some time during the Grade 12 course. Students could be exposed to such assembler commands as loading and storing accumulators, incrementing registers, branching on conditions, logical operations, various addressing techniques, and arithmetic operations. A discussion of round off and truncation, and their effect on error, should be included in any topic dealing with calculation. Although a short unit that contrasted a variety of languages would be of value, it is not intended that additional languages be introduced. The objectives of the course could best be met by fully utilizing one language.

Although it is not anticipated that the exploration of the sociological implications of the impact of computers will be allocated much class time, the time spent on this topic should be carefully planned so that students are aware of its importance. Assignments and reports on social issues are useful to students, but they should not replace intensive classroom interaction. Most students enjoy relating their interest in the computer to how it can be used in a practical setting.

The teacher's expectations should be clearly outlined in advance of the assignment of any written work. Written assignments should be carefully marked for both content and style. In order to receive a passing mark, student assignments should demonstrate a reasonably good understanding of an issue and be well written.

Suggested Time Frame

The accompanying chart presents a suggestion for the percentage of class time to be spent on each of the broad areas outlined above for these two courses.

Computer Science and Technology, Grade 11 (Advanced)	Per Cent of Class Time
1. Introduction to Programming	15
2. Programming Techniques	5
3. Problem-solving	40
4. Impact of Computer Technology	5
5. Inside the Computer	5
6. Elements of Computer Electronics	15
7. Applied Logic	5
8. Use of Circuits to Create Information in Code	10

Computer Science, Grade 12 (Advanced)	
1. Advanced Programming	10
2. Planning Logically	10
3. Developing Diverse Applications	50
4. Impact of Computer Science	5
5. Converting Program Code	5
6. Computer Architecture	5
7. Low-Level Languages	10
8. Careers and Further Studies	2
9. Personal Communication Skills	3*

*The presentation of this topic should be integrated with that of the other topics in the course wherever possible.

Computer Technology, Grade 12 (Advanced)

Introduction

This course should provide students with opportunities to apply number and logic theory to circuit modules to carry out practical tasks. The principles of electronic communication, types of power, encoding, decoding, and timing devices should be examined in the total context of microtechnology.

Students who have a good background in mathematics, physics, and computer studies will have the opportunity to acquire in-depth knowledge of computer hardware and the principles involved in its design. Such students might continue on to university courses in engineering or to courses leading to professions in which a technological background is extremely useful (e.g., medicine, dentistry, veterinary medicine).

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in fifteen broad areas.

1. *Logic modules*

Students should review their understanding of logic modules and circuits, including the following aspects:

a) the principles of AND, OR, NOT, and XOR (exclusive OR) modules;
b) the structure of the half adder, the full adder, binary subtraction, and R-S flip-flop circuits.

2. *Combining gates*

Students should learn the function of a variety of gates so that they are able to:

a) develop a representation of the circuitry of TTL and CMOS gates;
b) implement R-S flip-flops using NOR gates;
c) implement R-S flip-flops using NAND gates;
d) understand the principles of bipolar and field-effect transistors and their use in computer circuitry.

3. *Electronic communication*

Students should examine the use of electronics in teleprocessing, as well as the various types of display devices and methods, so that they are able to:

a) describe in general terms a number of automation systems or approaches;
b) develop some appreciation for a number of the major problems and current solutions to the electronic communication of data;
c) compare the various types of multidiode displays (e.g., the matrix and seven-segment types).

4. *Logic circuits*

Students should increase their understanding of the use of logic in the computer and of the ways of developing logic circuits so that they are able to:

a) develop truth tables for multigate logic circuits;
b) develop specific circuits from truth tables (adders, subtracters);
c) develop truth tables from logic equations;
d) substitute one type of gate for another, while obtaining the same results;
e) design an R-S flip-flop using a transistor inverter.

5. *Computer power supplies*

Students should compare the various types of power supplies used in computers in order to better understand their availability and applications. As a result of their study, students should be able to:

a) recognize the features and limitations of battery-powered operation;
b) outline the principles of alternating current and transformers;
c) illustrate and describe rectifier circuits and polarity of output;
d) relate to the microcomputer the technology of ripple filtering and voltage regulation;
e) formulate an explanation of voltage-doubling circuits;
f) identify the need for "switching" power supplies.

6. *Circuit design*

Students should be able to apply the concepts that they have learned to the design and construction of a variety of practical logic and power-supply circuits.

7. *Using Boolean logic*

After a review of Boolean logic students should be able to apply its use in computer circuitry. They should be able to:

a) interpret Boolean expressions involving inverted gates and apply De Morgan's theorems;

b) derive logic circuits from given truth tables and vice versa;
c) group together flip-flops to make registers in order to perform such tasks as binary counting, shifting, and data transfer (gated, master-slave, D and J-K flip-flops).

8. *Multivibrators and registers*
Students should learn the principles and applications of various types of multivibrators and explore the use of registers in the microprocessor. They should be able to:

a) contrast the principles of astable and monostable circuits for timing purposes;
b) illustrate common techniques for altering data within registers, such as counting, transferring, and shifting.

9. *Coding and decoding electronically*
Students should acquire a sufficient understanding of the various types of encoders and decoders so that they are able to apply these basic principles to the design of a computer. They should be able to:

a) identify the distinguishing features of the major codes used in computing (BCD, EBCDIC, ASCII, hexadecimal);
b) apply logic-circuit principles for encoding (BCD), decoding (BCD, hexadecimal), and multiplexing data;
c) appreciate that complex processes consist of a sequence of individual events;
d) relate to the microprocessor the function in logic circuits of clocking cycles and multiphase clock pulses.

10. *Digital signals, analog signals, and robots*
Students should relate digital and analog signals to input and output devices, particularly devices associated with process control such as robots. Students should be able to:

a) contrast analog signals with digital signals;
b) describe how sensors convert their input into either digital or analog signals;
c) illustrate or describe how the computer can receive, interpret, and respond to such information;
d) become aware of sample computerized process-control operations;
e) illustrate or explain the various functions of an electromechanical robot (transfer, transform, turn, screw, crush, grasp, etc.);
f) apply technical and computer techniques to enhancing the performance of a robot.

11. *The computer as a system*
Students should synthesize various concepts that they have learned to develop the idea of the computer as a complete system. They should be able to:

a) relate the term *architecture* to the description of the make-up of a typical computer;
b) describe in general terms the characteristics and function of an instruction set for a microprocessor;
c) discuss the features and limitations of various modes of memory (bubble, core, solid state);
d) discuss the features of readouts such as CRT, LED, and LCD.

12. *Uses of the microprocessor*
Students should have the opportunity to explore the use of the microprocessor in fields directly related to or closely allied with technology. They should be able to:

a) understand the use of the microprocessor in computer-assisted design (CAD) and computer-assisted manufacturing (CAM);
b) identify components of an automobile that lend themselves to the utilization of a microprocessor;
c) identify those operations in a processing system that could be managed by a microprocessor (process control);
d) describe ways in which a microprocessor and robots interact to carry out certain tasks.

13. *Practical applications*
Students should apply some of the technical principles that have been outlined in class to the needs of people. They should be able to:

a) identify and either discuss or write formal essays or reports on the impact that technology is having on people and on the economy;
b) develop a design for an application that, if implemented, would provide considerable benefit to (i) a person with a handicap and/or (ii) industry;
c) construct or fabricate necessary hardware and program, test, and actually implement the application designed in (b) above.

14. *Personal communication skills*
Students should be provided with opportunities to enhance and develop confidence in their communication skills by practising listening, speaking, reading, and writing. They should be able to:

a) listen carefully to and follow a series of oral technical instructions;

b) listen and react critically to presentations of ideas, plans, strategies, and so on for designing and/or implementing an application;
c) read and follow instructions such as those found in a manual that outlines the assembling, testing, maintenance, or repair of technical devices;
d) read and interpret orally for others a range of materials (technical manuals, descriptions of sociological issues, etc.);
e) research and prepare formal reports or essays on topics and issues related to computers.

15. *Careers and further studies*
Students should become aware of career applications of the skills and knowledge obtained in this course and of further courses or training offered in computer technology, including the following:

a) the ways in which student skills and knowledge might be used in part-time employment or in a future course in co-operative education;
b) the variety of careers in which computer skills could be used;
c) courses and programs that could be taken to further develop their aptitude, interests, skills, and knowledge in the dynamic field of computing.

Teaching Suggestions for Computer Technology, Grade 12 (Advanced)

Since this course emphasizes a systems approach to circuit blocks, it is recommended that activities focus on projects and laboratory work. It is useful to equip the laboratory with a suitable number of commercial logic trainers and/or microprocessor trainers. Computer programs might simulate combinations of logic blocks and CAD.

Laboratory circuits can be constructed from perforated boards, wiring boards (Bimboard, Protoboard, etc.), and printed circuit boards. The latter can be prepared photographically or with masking tape, paint, and ink. Switches can be used to generate the two-state logic levels for illustrating gating principles.

Gating circuits can be constructed either from discrete components or integrated circuits. Examples of situations in which logic circuits or switching circuits can be applied should be used to illustrate industrial applications.

Films and other audio-visual materials should be used when the introduction or overview of the course is taught. Library research projects should also be part of the work in this section of the course. Student presentations (e.g., seminars, essays, posters) are effective ways of covering the material dealing with the history of automation and modern computers.

It is important for students to experiment with up-to-date electronic components. They can do this by building interesting and useful projects with the aid of project books and electronics magazines. For example, they can design and build a relatively simple calculating device using available materials. However, for those topics for which hardware construction projects are not appropriate, the use of work sheets, chalkboard drills in small groups, individual assignments, and short daily drills are effective.

There are many activities that might be planned for this course. For example, students can be asked to:

- construct a binary counter using type D flip-flops;
- connect a seven-segment decoder and readout to indicate the state of a binary counter or register;
- construct a timer using the 555 integrated circuit or its equivalent;
- construct a hexadecimal encoder using simple pushbutton-type keys and a seven-segment display;
- construct a free-running clock circuit.

Where a microprocessor or minicomputer system is available, students can construct basic peripheral interface experiments and prepare programs for them. Where time and resources permit, students can design and construct a microprocessor system.

The function of the microprocessor should be emphasized in this course. Its architecture should be explored so that students can relate the function of the support chips to it. A series of experiments and projects can be done involving interfacing. This will highlight the control function of the microprocessor.

Students should be encouraged to explore the function of the microprocessor in robotics. Its function as a dashboard control element in today's automobile might be used as another example for study.

Since this course is intended to be fairly theoretical, more time should be spent on theory and experiment than on project work. Normally about 60 to 70 per cent of class time is spent on theory and experiments. To accomplish this, teachers may wish to increase their demonstration of material and reduce the assigning of projects.

Suggested Time Frame

The accompanying chart presents a suggestion for the percentage of class time to be spent on each of the broad areas outlined above for this course.

Computer Technology, Grade 12 (Advanced)	Per Cent of Class Time
1. Logic Modules	2
2. Combining Gates	5
3. Electronic Communication	5
4. Logic Circuits	10
5. Computer Power Supplies	5
6. Circuit Design	5
7. Using Boolean Logic	10
8. Multivibrators and Registers	5
9. Coding and Decoding Electronically	5
10. Digital Signals, Analog Signals, and Robots	10
11. The Computer as a System	13
12. Uses of the Microprocessor	5*
13. Practical Applications	5*
14. Personal Communication Skills	10*
15. Careers and Further Studies	5*

*The presentation of this topic should be integrated with that of the other topics in the course wherever possible.

Data Processing Techniques, Grade 11 (Advanced)

Introduction

This course should provide students with opportunities to acquire specific programming skills, with special emphasis on applications programs related to business. Students should acquire a sound basis for writing high-quality, structured programs that contain suitable safeguards and are written in an appropriate style. Business concepts, in addition to those related to programming, should be included to provide background for students.

This course will be best suited to students who wish to concentrate on information processing rather than on the technical and logic concepts involved in Computer Science and Technology, Grade 11 (Advanced). Students might use the skills that they acquire in this course in either a business or professional environment, whether on graduation, in part-time employment, in co-operative education programs, or in a career following their formal education.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives are listed in fourteen broad areas.

1. *Structured programming*

Students should develop the basic skills required for creating well-structured programs. They should be able to:

a) apply basic programming structures (sequence, selection, and repetition) where appropriate;
b) identify and create suitable codes to (i) handle input and (ii) format output;
c) identify and use appropriate language structures to execute the necessary processing;
d) use, where appropriate, header lines, prompts, detail lines, end-of-data or end-of-file routines, summary lines, and end-of-job indicators.

2. *The modular approach*

Students should learn to use a sound, hierarchical, modular approach to program design so that they are able to:

a) set up a "driver" module (sometimes called a "top-down"or "mainline logic" module);
b) establish suitable program modules of a manageable size (ten to fifteen instructions);
c) design each module to have only one entry point and one point of exit;
d) pass control from one module to the next within the overall hierarchical structure of the program.

3. *Testing programs*
Students should learn to use one or more methods of testing all program modules. They should be able to:

a) use both top-down and bottom-up testing;
b) create data or conditions to assure that all parts of the program are tested, including the generation of output to prove the satisfactory testing of each module;
c) predict and validate output;
d) run the program being tested parallel to another system, using actual data.

4. *Debugging*
Students should learn to identify a number of classes of error (logic, data limit, formatting) and to use a variety of debugging strategies (flagging points in the program, traces, "binary search" type of run, etc.).

5. *Programming style and documentation*
Students should be aware of the standards for good internal documentation and an appropriate programming style. They should be able to:

a) provide a suitable description for a program;
b) provide to an accepted industrial standard internal-documentation components within the listing of a program;
c) write programs with suitable comments to identify key modules or special processing routines;
d) either list variable names describing their content or use meaningful names, fully spelled out;
e) use indentations in the listing, where appropriate.

6. *External documentation*
Students should learn to appreciate the need for and gain practice in developing external documentation. They should be able to:

a) provide the necessary information to back up programs;
b) provide instructions on how to run a program, including the need for the accessibility of specific files;
c) create lists of messages that might be generated by a program and the action that the user should take as a result of each message.

7. *Complex programming*
Students should continue to develop their programming skills by learning additional programming functions in the language being used and by using techniques to represent the logic being used. They should be able to:

a) use a problem-solving strategy;
b) sketch, for reference purposes, some logic representation such as a HIPO diagram or hierarchical tree during the development of a complicated program;
c) convert a given flowchart solution of a program into a properly structured program;
d) understand and, in some cases, create logic representations such as flowcharts, decision tables, tree diagrams, and PLEX diagrams.

8. *Computer concepts and architecture*
Students should acquire a conceptual awareness of the internal architecture of the computer so that they are able to:

a) illustrate or describe the functions of the various components of a microcomputer;
b) contrast the function of a compiler with that of an interpreter;
c) demonstrate a conceptual understanding of the structure and function of the parts of a microcomputer;
d) contrast the functions of program instructions with those of operating-system instructions;
e) be aware of ways of making software portable (e.g., disc, ROM, etc.), and the need to isolate into as few modules as possible routines handled differently by different computers;
f) review or learn for the first time the basic electronics structure of computer logic (gates and flip-flops).

9. *File management*
Where facilities exist, students should obtain a thorough grounding in the structure of files, their organization, and their maintenance. They should be able to:

a) illustrate the characteristics of a disc and/or tape file and records (file directories, file names, headers, trailers, tracks, sectors, cylinders, blocks);
b) describe in conceptual terms the interrelationship between the computer and an electronically stored file (access times, parity, transfer rates, buffers, channels, recording density);

c) create, maintain, merge, and edit sequential, random, and/or indexed sequential files;
d) apply a variety of advanced programming concepts related to file management (menus, searches, sorts, on-line transactions, audit-trail file production);
e) generate a report from an electronically stored file after ensuring that the correct or current version of the file is in use;
f) use good judgement in identifying the need for and actually carrying out the backing-up of a file;
g) use available operating systems and file-processing utilities.

10. *Programming systems*

Students should design and write one or more "programming systems", including a series of programs that have access to and can update common data bases.

11. *Computer solutions to complex information processing problems*

Students should become aware of and be able to describe current computer-related concepts and practices. They should be able to:

a) contrast flat files with files controlled by a database management system;
b) contrast distributed processing with a centralized time-sharing operation;
c) understand the principles and function of word processing, "electronic mail", and electronic spread sheets.

12. *Personal communication skills*

Students should be encouraged to enhance and develop confidence in their ability to communicate. They should be provided with opportunities to practise listening, speaking, reading, and writing so that they are able to:

a) listen critically to discussions on computer-related issues and participate in a thoughtful, reasoned manner;
b) research computer-related topics and write well-organized, well-documented reports or essays.

13. *Careers and further study*

Students should become aware of career applications of the skills and knowledge obtained in this course and of further courses or training offered in information processing. They should be aware of:

a) ways in which student skills and knowledge might be used in part-time employment or in a future course in co-operative education;
b) the variety of careers in which computer skills could be used;
c) courses and programs that could be taken to further develop their aptitude, interests, skills, and knowledge in the dynamic field of computing.

14. *Impact of computers on society*

Students should become aware of the similarity of some of the application programming being done in class to applications that are having an impact on society. They should be able to:

a) identify and either discuss or write a formal essay on at least three issues related to the social implications of computer applications;
b) identify and discuss in general terms the ways in which computers can be programmed to assist special groups, such as exceptional students, the handicapped, the aged, and those who are socio-economically disadvantaged.

Data Processing Systems Analysis and Design, Grade 12 (Advanced)

Introduction

This course should provide students with opportunities to acquire a broad perspective of systems, as well as specific skills directly related to this challenging field. These include the skills of fact finding through surveys and interviews, identifying problem areas, developing solutions (which may or may not include the use of a computer), and establishing strategies for the implementation and maintenance of the new or revised system. The course will be of value to those students who are keenly interested in computing, especially programming, as well as to other students (e.g., secretarial students) who wish to integrate the concepts to be learned with their other skills and abilities.

Objectives

A course developed to reflect the intent stated above should assist students in achieving the following objectives. For convenience these objectives have been listed in seven broad areas.

1. *Introduction to systems analysis and design*

Students should be provided with an introduction to systems analysis and design, with the emphasis placed on the importance of effective communication among the people involved in the design process. Students should be able to:

a) describe what a system is and outline some of its components;
b) describe the need for effective communication skills;
c) define a subsystem and illustrate the interrelationship among subsystems;
d) contrast the problems involved in updating a current system with those involved in creating a new system;
e) describe the role of a systems analyst in the business environment;
f) demonstrate an awareness of the educational program and the types of experience needed to become a systems analyst;
g) explain why systems development is often referred to as a life cycle.

2. *Systems analysis*

Students should learn about and gain some experience in problem identification, the initial phase of systems analysis. They should be able to:

a) define a problem in terms of goals, objectives, and measures of performance;
b) demonstrate techniques that could be used to compare the advantages of creating a totally new system with those of modifying a current system;
c) develop ways of identifying current problem areas;
d) explain why it is important to be able to communicate with the "client" in his/her own metaphor;
e) outline strategies to document the current system (systems flowcharts, the collection of forms currently in use, obtaining job specifications and organization charts, the identification of objectives, etc.);
f) develop and execute suitable interview strategies;
g) classify any problems that are discovered (e.g., those related to people, communication, data manipulation, bottlenecks).

3. *Analysis strategies*

Students should learn a variety of analysis strategies so that they may apply them to:

a) discover the essence of a problem;
b) evaluate an internal organizational structure;
c) identify the group dynamics of an organization;
d) identify additional data that are required and develop appropriate techniques to obtain those data;
e) create effective questionnaires and carry out effective interviews;
f) identify and evaluate the relationship of the system to, and the effect that the system has on, staff working at the periphery of the system;
g) obtain equipment specifications and cost information.

4. *Developing solutions*

Students should design a number of solutions to problems found in a system and be prepared to recommend one of the solutions and to defend their choice based on a range of criteria. They should be able to:

a) develop and carry out feasibility studies;
b) create an iterative process involving management and personnel so that solutions evolve;
c) use a variety of design components in a solution (goals; performance measures; and methods for redesigning source documents, reorganizing the flow of information, matching hardware to needs, and matching software to need);
d) where the computer forms part of the solution, develop program specifications, including processing procedures (e.g., data-validity checks, internal controls, auditing);
e) develop hardware specifications and acquisition alternatives (leasing, purchasing, maintenance contracts);
f) develop retraining programs for staff;
g) identify the need for and make allowances for future growth considerations;
h) make recommendations for the review and maintenance of the proposed system;
i) prepare a comparative analysis of the system alternatives that have been developed, recommend one of the alternatives, and indicate the reasons for the choice.

5. *Design implementation*

Students should be provided with opportunities to practise applying implementation steps. They should be able to:

a) identify the specific tasks to be carried out;
b) develop a time line (PERT, critical path) for the carrying out of these tasks;
c) finalize systems flowcharts;
d) design or revise forms;

e) set up training programs for personnel;
f) maintain an ongoing dialogue with the personnel affected by the new system;
g) establish suitable backup routines;
h) supervise the testing of the system, including parallel runs and the acceptance test.

6. *Post-implementation activities*
Students should learn and obtain experience in conducting post-implementation activities by:

a) identifying the need for post-implementation procedures;
b) verifying that all necessary procedures have been completed (i.e., that the goals as set out were achieved);
c) supervising the completion of the documentation;
d) establishing a procedure for maintenance and review.

7. *Personal communication skills*
Students should be encouraged to enhance and develop confidence in their ability to communicate. They should be provided with opportunities to practise listening, speaking, reading, and writing so that they are able to:

a) listen to and evaluate not only the words that are being spoken but the subtle non-verbal communication that often is provided during a discussion or interview;
b) clearly express points that have to be made, perhaps after preparing an outline of what has to be said;
c) read diverse types of materials (from sections of books ranging from the psychology of change to technical manuals) and write summaries of what has been read;
d) prepare formal reports that are soundly structured and written in language appropriate for "the client".

Teaching Suggestions for Data Processing Techniques, Grade 11 (Advanced), and Data Processing Systems Analysis and Design, Grade 12 (Advanced)

Today's employers seek employees who are able to undertake tasks on their own and to approach them in a methodical way. To perform effectively, such employees require the necessary background and knowledge of general business procedures, as well as the ability to identify and carry out the "obvious" next task. They also need to know what is expected of them and to have a good understanding of the overall structure in which they are involved.

Courses in data processing techniques and applied systems design should therefore provide students with opportunities to:

- develop problem-solving skills that include identifying the problem, identifying objectives, developing possible solutions, evaluating alternatives, implementing one of these possible solutions, and assessing the success of the solution chosen;
- acquire decision-making skills;
- understand the flow of information in business and among businesses;
- learn business procedures;
- understand the interrelationships of the various types of operations and procedures that make up a system;
- improve their ability to communicate effectively in oral, written, and graphic forms;
- develop the ability to establish independently the progression of stages involved in accomplishing a complex task and to see that the task is done.

The complex tasks that students will face on the job involve a broad variety of operations and procedures. These may include the flow and management of data, the processing of data, and the integration of human activity and devices. Students should be fully aware that a system may or may not require the use of a computer.

These courses can be taught using a spiral approach; that is, after students have had a brief overview of an applications problem or systems analysis and design assignment, they could apply what they have learned to developing solutions. As they work on their projects, they will learn additional concepts, some of which should be covered in more depth or detail. As well, each subsequent project should be more complex than the one preceding it.

Teachers should try to help their students develop many interrelated skills, including group dynamics. If possible, they should meet with each student on an individual basis to discuss the strengths that he/she has developed and those areas in which improvement is required. The degree of success that students have in developing independence, flexibility, and decision-making skills will depend not only on their aptitude and potential, but also on the time that their teachers can devote to motivating and helping them.

Systems design requires the development of a wide variety of skills. Obviously not all students will develop all these skills at an equal rate or to the same level of competence. For example, some students may have difficulty with analytical work, but will be able to complete high-quality work involving the graphic representation of layouts, flowcharts, organizational charts, and so on, as well as the collection and organization of information. However, all students should be encouraged to take pride in the quality of the design of their structured programs and of their documentation.

Different applications in systems design have different goals and therefore require different emphases. For example, a school-attendance system might have fewer types of input than a payroll system. Teachers should attempt, therefore, to select a wide range of systems projects so that as many design components as possible receive adequate attention. Student projects might include assignments based on the following themes: attendance; timetabling; the school store; report cards; inventory control; cash control; food-services management; the library; the school book-distribution system; or such accounting projects themes as the general ledger, the subsidiary ledgers, statements and reports, payroll, bank reconciliations, and cash flow. A number of systems projects based on these themes could result in a non-computerized system. However, many of the projects could, and should, be computerized.

One problem that teachers and students often discover is that seemingly straightforward systems projects grow into systems that are much larger than were originally anticipated. For example, a project based on subsidiary ledgers could include data collection, reporting, and updating in such subsystems as cash receipts, cash payments, purchases, sales and invoicing, ledger and subsidiary updates, credit checks, and aging of accounts. It soon becomes obvious that major systems must link up with each other. For example, the inventory-control system has to link with the system that contains the sales-order subsystem, the accounts-receivable subsystem, and the purchasing and accounts-payable subsystem.

In order to capitalize on the diverse skills found in the classroom, teachers can organize students into project teams, combining the students' varying abilities to organize, analyse, and complete detailed work. In evaluating student progress, teachers should take into consideration the diverse strengths of their students and consider allocating a greater proportion of the students' final marks to those areas in which they show particular strengths.

In order to broaden their outlook, students should be asked to evaluate and/or design systems that relate both to business and to the school — their immediate environment. Through the completion of as many practical projects as they are able to produce, students will be able to see their work being applied to particular cases. This will give them the opportunity to gain the experience that comes only from actual implementation, to become involved in realistic situations to which they can relate, and to benefit from the motivation that comes from personal involvement in practical projects.

Teachers should emphasize that systems must be designed for the user. Therefore, good systems design includes data-validation procedures, source documents that are easy to use, and reports that are meaningful and easy to understand. This emphasis should also be stressed in any computer programs that students write as part of a system. Thus, such programs should incorporate meaningful prompts, menus, and templates to facilitate the accurate use of the program, as well as error traps and recovery techniques to deal with errors.

Suggested Time Frame

The accompanying chart presents a suggestion for the percentage of class time to be spent on each of the broad areas outlined above for these two courses.

Data Processing Techniques, Grade 11 (Advanced)	Per Cent of Class Time
1. Structured Programming	15
2. The Modular Approach	5
3. Testing Programs	3
4. Debugging	5
5. Programming Style and Documentation	7
6. External Documentation	5
7. Complex Programming	10
8. Computer Concepts and Architecture	10
9. File Management	3*
10. Programming Systems	25
11. Computer Solutions to Complex Information Processing Problems	3
12. Personal Communication Skills	5†
13. Careers and Further Study	2†
14. Impact of Computers on Society	2†

Data Processing Systems Analysis and Design, Grade 12 (Advanced)	Per Cent of Class Time
1. Introduction to Systems Analysis and Design	10
2. Systems Analysis	25
3. Analysis Strategies	15
4. Developing Solutions	20
5. Design Implementation	15
6. Post-Implementation Activities	10
7. Personal Communication Skills	5†

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*This topic should be expanded significantly if suitable hardware is available.

†The presentation of this topic should be integrated with that of the other topics in the course wherever possible.

Appendix A: Safety and Ergonomics

It is the policy of the Ministry of Education that any equipment used by students should conform to the highest possible safety standards. Microcomputers used by students should be approved by the Canadian Standards Association (CSA) and should meet or exceed the safety requirements that have been established as the criteria for Ontario classroom microcomputers. In addition, it is the responsibility of the school principal to ensure that the electrical connections used to power computers meet CSA standards and are used according to Ontario Hydro specifications. Classroom procedures regarding the connecting and disconnecting of equipment to power sources should be established and clearly communicated to students.

There has been considerable public concern regarding the safety of microcomputers, terminals, and word processing stations. The major concern focuses on the display screen or cathode-ray tube (CRT). Ontario has one of the highest standards of safety regarding electromagnetic radiation emitted by CRTs, and it is the policy of the Ministry of Education that these safety standards be implemented and maintained in all equipment containing CRTs. Colour monitors using tube-type circuitry and/or remanufactured picture tubes should be used only after radiation emission levels have been checked.

Educators should be aware of the particular reaction that some students have to the flicker of the CRT that results from the changing display on the screen. In most models of microcomputers these changes occur about sixty times per second, a speed so swift that most people would not notice it. However, some students suffering from epilepsy may have some reaction to this flicker. (One study suggests that only 5 per cent of those with epilepsy are sensitive to the flicker of the changing display on a microcomputer.) Thus, it is advisable for students suffering from epilepsy to consult with their physicians before using a device equipped with a CRT. Although research in this area is ongoing, it appears that the best solution is to use equipment in which the display material changes at a rate of about one hundred times per second and to position students who might be susceptible at least 1.5 m to 2 m from the screen.

Appendix B: ONTERIS

In addition to the preceding considerations, the following points should be observed in the use of microcomputers in schools:

- Microcomputers should be positioned so that there is a minimum of reflective glare from windows or artificial lighting. If necessary, anti-glare acrylic sheets should be obtained and placed over the screens.
- A student who is to spend a significant amount of time at a microcomputer should be seated in an adjustable chair so that he/she may sit comfortably, with good back support. The student's feet should rest on the floor or on a sloping footstool, and the weight of the upper part of the student's legs should be evenly distributed along the chair.
- The height of the keyboard should be slightly higher than the student's elbows when these are held in a relaxed position by the student's side. The student's forearm should slope slightly upward when the student's hands are placed over the keyboard. The space bar of the keyboard should be between 18 cm and 20 cm from the student's body.
- Some students wearing glasses might have difficulty viewing the screen, depending on the type of lens in the glasses. These students should check with their ophthalmologist or optometrist for further direction in this regard.
- CRT monitors should be of recent design to assure the safest possible environment. Large monitors should be a reasonable distance from the student to avoid unnecessary eyestrain.

Supervisory personnel, principals, department heads, and teachers will find it useful to access ONTERIS (Ontario Educational Research Information Service) to identify sources of support materials. The database entries include research studies, curriculum development articles, school board courses of study, curriculum resource documents, and teachers' reference manuals. These materials will provide additional assistance to teachers and school board teams preparing local courses of study.

Educators are encouraged to submit documents originating at the local or board level for recording in the data base. Such documents should be submitted through the channel established by the board.

ONTERIS may be accessed via an appropriate terminal or microcomputer. Further information about ONTERIS may be obtained from:

Co-ordinator, Information Resources
Information Centre, Research Branch
Ministry of Education
Mowat Block, 13th Floor
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ISBN 0-7743-8794-7 83-126